MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY.

VOL. LXIV. FEBRUARY 12, 1904. No. 4.

ANNUAL GENERAL MEETING.

Professor H. H. TURNER, D.Sc., F.R.S., PRESIDENT, in the Chair.

The Report of the Auditors of the Treasurer's accounts for the year 1903 was read, and is given on p. 258.

The Annual Report of the Council was partly read; see pp. 255 to 387.

The Address was delivered by the President, after which the Gold Medal was handed to His Excellency the American Ambassador, for transmission to Professor G. E. Hale, to whom the Medal had been awarded for his method of photographing the Solar Surface and other astronomical work.

The Society then proceeded to the ballot for Officers and Council for the ensuing year, the names of those elected being given on p. 402.

The thanks of the Meeting were given to the retiring Members of Council, and also to the Auditors of the Treasurer's Accounts and the Scrutineers of the Ballot.

J. D. Bharda, New High School, Bombay, India;
Tyson Crawford, 35 Ludgate Hill, E.C.;
E. Vincent Heward, Hereward Cottage, Westgate-on-Sea, Kent;
Eber Jachin Sharpe, 164 Colum Road, Cardiff, South Wales;

Ernst Spiegel, 27 Fitzjohn's Avenue, Hampstead, N.W. ; and
Philip Edward Vizard, Belsize Lodge, Belsize Lane, Hampstead, N.W.,

were balloted for and duly elected Fellows of the Society.

The following Candidates were proposed for election as Fellows of the Society, the names of the proposers from personal knowledge being appended :—

John Borthwick Dale, M.A., Assistant Professor of Mathematics, King's College, London, "Myosotis," New Malden, Surrey (proposed by Major P. A. MacMahon) ;
Rev. William Charles Eppstein, M.A., Head Master, Reading School, Berks (proposed by Rev. J. M. Bacon) ;
Walter Nuttall, B.A., Schoolmaster, Hallfold, Whitworth, Rochdale (proposed by Rev. E. Wainwright) ; and
William Edward Rolston, Solar Physics Observatory, South Kensington, S.W. (proposed by W. J. S. Lockyer).

Report of the Council to the Eighty-Fourth Annual General Meeting of the Society.

The following table shows the progress and present state of the Society :—

	Compounders	Annual Subscribers	Total Fellows	Associates	Patron and Hon. Members	Grand Total
1902 December 31	257	383	640	44	1	685
Since elected	+ 3	+26	...	+ 4	+ 2	...
Deceased	− 8	−10	...	− 1	...	...
Resigned	...	− 8	...	...	...	...
Removals	+14	−14	...	...	...	...
Expelled	...	...	...	...	...	...
1903 December 31	266	377	643	47	3	693

Mr. Maw's Account as Treasurer of the Royal

RECEIVED.

	£ s. d.	£ s. d.
Balances, 1903 January 1:—		
At Bankers', as per Pass-book	231 16 9	
Country Cheque not credited till 1903 ...	8 10 6	
At Bankers', on deposit	300 0 0	
		540 7 3
Dividends on £1,250 Metropolitan 3-per-cent. Stock	35 12 7	
Dividends on £932 19 0 Metropolitan 2½-per-cent. Stock	22 3 1	
Dividends on £3,400 East Indian Railway 3-per-cent. Debenture Stock	96 17 11	
Dividends on £3,200 London and North-Western Railway 3-per-cent. Debenture Stock	90 8 0	
Dividends on £4,000 Midland Railway 2½-per-cent. Debenture Stock	94 3 4	
Dividends on £1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock	52 10 11	
Dividends on £1,650 Commercial Gas Co. 3-per-cent. Debenture Stock	47 0 6	
Dividends on £500 Lancashire and Yorkshire Railway 3-per-cent. Preference Stock... ...	7 1 10	
Interest on £300 on Deposit at Bankers'	2 0 3	
		447 18 5
Received on account of Subscriptions:—		
Arrears	134 8 0	
Annual Contributions for 1903	554 8 0	
„ „ in Advance	10 10 0	
Admission Fees	56 14 0	
First Contributions	39 18 0	
		795 18 0
Composition Fees		260 8 0
Sales of Publications, &c.:—		
At Williams and Norgate's, 1902	7 13 11	
At Society's Rooms, 1903	58 0 6	
Sales of Photographs	38 11 0	
		104 5 5
Income Tax refunded by Commissioners of Inland Revenue		28 13 7
Due to Assistant Secretary on account of Turnor and Horrox Fund		2 8 3
		£2,179 18 11

Examined and found correct, 1904 Jan. 5:
W. J. S. Lockyer,
C. Thwaites,
A. C. D. Crommelin.

Astronomical Society, from 1903 *January* 1 *to December* 31.

PAID.

	£	s.	d.	£	s.	d.
Assistant Secretary: Salary	250	0	0			
„ „ for assistance in editing Society's Publications ...	50	0	0			
				300	0	0
House Duty	2	12	6			
Fire Insurance	9	9	6			
				12	2	0
Printing, plates, &c., *Monthly Notices* (Spottiswoode & Co.)	513	18	10			
Photo-engraving, *Monthly Notices* (Dent & Co.) ...	6	2	9			
Printing, &c., Appendix to *Memoirs* (Harrison & Sons)	16	13	6			
Plates for Appendix to *Memoirs* (London Stereoscopic Co.)	10	9	6			
Printing, &c., Appendix to *Monthly Notices* (Harrison & Sons)	3	3	6			
Printing, &c., List of Fellows and Miscellaneous (Spottiswoode & Co.)	23	9	6			
				573	17	7
Computation of Ephemerides in *Monthly Notices* ...				15	0	0
Turnor and Horrox Funds: Purchases for Library	22	3	8			
Binding books in Library	28	19	10			
				51	3	6
Reproduction of Photographs, Hinton & Co. ...				30	12	8
Cataloguing astronomical literature for the International Catalogue of Scientific Literature ...				30	0	0
Clerk's Wages	52	0	0			
Postage and Telegrams	83	15	5			
Carriage of Parcels, &c.	2	14	11			
Stationery (Spottiswoode & Co.)	9	0	6			
Sundry Stationery and Office Expenses	3	15	5			
				151	6	3
Expenses of Meetings	19	14	0			
Lantern Expenses	7	12	6			
Time Signal, Rental of Wire	5	0	0			
				32	6	6
Special Allowance to Assistant Secretary during progress of work carried out by H.M. Office of Works				36	0	0
House Expenses	61	18	5			
Coals and Gas	52	12	2			
Electric Light Expenses	5	16	11			
Sundry Fittings and Repairs	19	5	5			
Sundries	5	12	8			
				145	5	7
Partition in Instrument Room	17	10	0			
Decorating	9	19	6			
Restoring Oil Painting	2	18	6			
				30	8	0
Lee and Janson Fund: grant to Mrs. Martin				20	0	0
Purchase of £500 Lancashire and Yorkshire Railway 3-per-cent. Preference Stock at 93¾, including brokerage, &c.... ...				471	8	0
Cheque-book, Deductions on Cheques, &c. ...					11	4
Cheques outstanding, 1902 Dec. 31				16	19	6
Repayment to Assistant Secretary of amounts due 1902 Dec. 31 on Account of Petty Cash and Turnor and Horrox Fund				2	1	9
Balances, 1903 December 31:—						
At Bankers', as per Pass-book	246	9	5			
Country Cheque not credited till 1904 ...	9	16	0			
In hand of Assistant Secretary on Petty Cash Account	4	10	10			
				260	16	3
				£2,179	18	11

Report of the Auditors.

We have examined the Treasurer's accounts of receipts and expenditure for the year 1903, and have found and certified the same to be correct. The cash in hand on December 31, 1903, including the balance at the bankers', &c., amounted to 260*l.* 16*s.* 3*d.*

The invested property of the Society has been increased by the purchase of 500*l.* Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock.

The books, instruments, and other effects in the possession of the Society have been examined, and they appear to be in a satisfactory condition.

We have laid on the table a list of the names of those Fellows who are in arrear for sums due at the last Annual General Meeting, with the amount due against each Fellow's name.

(*Signed*) W. J. S. Lockyer.
C. Thwaites.
A. C. D. Crommelin.

1904 *January* 5.

Trust Funds.

The Turnor Fund: A sum of £464 18*s.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Horrox Memorial Fund: A sum of £103 6*s.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be used in the purchase of books for the Library.

The Lee and Janson Fund: A sum of £334 10*s.* 9*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given by the Council to the widow or orphan of any deceased Fellow of the Society who may stand in need of it.

The Hannah Jackson (née Gwilt) Fund: A sum of £309 18*s.* 6*d.* East Indian Railway 3-per-cent. Debenture Stock; the interest to be given in Medals or other awards, in accordance with the terms of the Trust.

Assets and Present Property of the Society, 1904 January 1.

	£	s.	d.	£	s.	d.
Balances, 1903 December 31:—						
At Bankers', as per Pass-book	246	9	5			
Country Cheque not credited	9	16	0			
In hand of Assistant Secretary on Petty Cash Account	4	10	10			
	260	16	3			
Less due to Assistant Secretary on account of Turnor and Horrox Fund...	2	8	3			
				258	8	0
Due on account of Subscriptions:—						
3 Contributions of 5 years' standing	31	10	0			
3 „ 4 „	25	4	0			
6 „ 3 „	37	16	0			
32 „ 2 „	134	8	0			
64 „ 1 „	134	8	0			
	363	6	0			
Less 5 Contributions paid in advance ...	10	10	0			
				352	16	0
Due for Photographs sold				2	11	0
Due from Messrs. Williams and Norgate for sales of Publications during 1903				9	4	5
£3,400 East Indian Railway 3-per-cent. Debenture Stock, including the Turnor Fund, the Horrox Memorial Fund, the Lee and Janson Fund, and the Hannah Jackson (née Gwilt) Fund.						
£3,200 London and North-Western Railway 3-per-cent. Debenture Stock.						
£4,000 Midland Railway 2½-per-cent. Debenture Stock.						
£1,860 Gas Light and Coke Co. 3-per-cent. Debenture Stock.						
£1,650 Commercial Gas Company 3-per-cent. Debenture Stock.						
£500 Lancashire and Yorkshire Railway 3-per-cent. Consolidated Preference Stock.						
£1,250 Metropolitan 3-per-cent. Stock.						
£932 19 0 Metropolitan 2½-per-cent. Stock.						
Astronomical and other Manuscripts, Books, Prints, and Instruments.						
Furniture, &c.						
Stock of Publications of the Society.						
Three Gold Medals.						

Stock in hand of volumes of the *Memoirs* :—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I. Part 1	8	...	XXXIII.	83	...
I. Part 2	42	...	XXXIV.	88	...
II. Part 1	51	3	XXXV.	52	...
II. Part 2	16	3	XXXVI.	125	8
III. Part 1	65	1	XXXVII. Part 1	268	7
III. Part 2	81	1	XXXVII. Part 2	214	8
IV. Part 1	76	3	XXXVIII.	200	1
IV. Part 2	89	3	XXXIX. Part 1	164	2
V.	62	3	XXXIX. Part 2	171	2
VI.	50	6	XL.	182	1
VII.	89	3	XLI.	317	1
VIII.	61	3	XLII.	158	3
IX.	63	3	XLIII.	157	...
X.	63	...	XLIV.	136	1
XI.	71	...	XLV.	172	...
XII.	77	...	XLVI.	147	2
XIII.	68	...	XLVII. Part 1	2	...
XIV.	292	...	XLVII. Part 2	18	...
XV.	56	...	XLVII. Part 3	2	...
XVI.	78	1	XLVII. Part 4	8	...
XVII.	60	1	XLVII. Part 5	8	...
XVIII.	60	...	XLVII. Part 6	9	...
XIX.	66	...	XLVII.	190	1
XX.	61	...	XLVIII. Pt. 1	222	...
XXI. Part 1	182	...	XLVIII. Pt. 2	223	1
XXI. Part 2	49	...	XLIX. Part 1	347	1
XXI.	27	...	XLIX. Part 2	234	2
XXII.	83	...	L.	220	2
XXIII.	67	...	LI.	243	...
XXIV.	75	1	LII.	274	2
XXV.	80	...	LIII.	274	...
XXVI.	90	1	LIV. App. I.	577	...
XXVII.	341	1	App. II.	591	...
XXVIII.	291	...	App. III.	630	...
XXIX.	333	1	App. IV.	678	...
XXX.	90	1	App. V.	682	...
XXXI.	66	...	Index to *Memoirs*	597	2
XXXII.	70	...			

Stock in hand of volumes of the *Monthly Notices* :—

Vol.	At Society's Rooms	At Williams & Norgate's	Vol.	At Society's Rooms	At Williams & Norgate's
I.	51	...	XXXIV.	65	1
II.	53	...	XXXV.	51	...
III.	...	...	XXXVI.	25	1
IV.	...	...	XXXVII.	30	3
V.	...	...	XXXVIII.	95	1
VI.	38	...	XXXIX.	95	...
VII.	2	...	XL.	103	2
VIII.	149	1	XLI.	103	5
IX.	23	3	XLII.	111	1
X.	170	1	XLIII.	108	2
XI.	181	...	XLIV.	110	2
XII.	104	1	XLV.	113	1
XIII.	176	2	XLVI.	107	...
XIV.	175	3	XLVII.	121	2
XV.	167	1	XLVIII.	117	...
XVI.	152	1	XLIX.	108	7
XVII.	164	...	L.	108	9
XVIII.	241	...	LI.	109	6
XIX.	51	...	LII.	106	10
XX.	31	...	LIII.	108	13
XXI.	16	...	LIV.	108	13
XXII.	30	...	LV.	119	...
XXIII.	17	...	LVI.	119	2
XXIV.	22	...	LVII.	122	2
XXV.	13	...	LVIII.	120	...
XXVI.	9	...	LIX.	128	2
XXVII.	3	...	LX.	131	3
XXVIII.	70	...	LXI.	128	3
XXIX.	50	...	LXII.	132	4
XXX.	61	2	LXIII.	137	4
XXXI.	90	...	1st Index ...	540	1
XXXII.	106	5	2nd „ ...	788	...
XXXIII.	86	...			
LIBRARY CATALOGUE				538	2
„ „ SUPPLEMENT				420	...

In addition to the above volumes of the *Monthly Notices*, the

Society has a considerable stock of separate numbers of nearly all the volumes. With the exception, however, of Vols. XXXVI. to LXIII., no complete volumes can be formed from the separate numbers in stock.

Celestial Photographs.

The following is a list of reproductions of Celestial Photographs published by the Royal Astronomical Society for sale to the Fellows :—

R.A.S. Ref. No.	Subject.	Photographed by
1	Total Solar Eclipse, 1889 January 1	W. H. Pickering
2	Total Solar Eclipse, 1893 April 16	J. M. Schaeberle
3	Total Solar Eclipse, 1886 August 29	A. Schuster
4	Nebulæ in the *Pleiades*	Isaac Roberts
5	Nebula M 74 *Piscium* (N.G.C. 628)	Isaac Roberts
6	Great Nebula in *Orion*	Isaac Roberts
7	Milky Way near M 11	E. E. Barnard
8	Milky Way near Cluster in *Perseus*	E. E. Barnard
9	Comet *c* 1893 IV. (Brooks), 1893 October 21	E. E. Barnard
10	Comet *a* 1892 I. (Swift), 1892 April 7	E. E. Barnard
11	Nebula about *η Argûs*	David Gill
12	Portion of Moon (Hyginus-Albategnius)	Lœwy and Puiseux
13	Comet *c* 1893 IV. (Brooks), 1893 October 22	E. E. Barnard
14	Comet *c* 1893 IV. (Brooks), 1893 October 20	E. E. Barnard
15	Comet *c* 1893 IV. (Brooks), 1893 November 10	E. E. Barnard
16	Comet *a* 1892 I. (Swift), 1892 April 26	E. E. Barnard
17	Comet *f* 1892 III. (Holmes), 1892 November 10	E. E. Barnard
18	Comet *a* 1892 I. (Swift), 1892 April 18	E. E. Barnard
19	Portion of Moon (Alps, Apennines, &c.)	Lœwy and Puiseux
20	Nebula in *Andromeda*	Isaac Roberts
21	*Jupiter*, 1892 September 26	Lick Observatory
22	Cluster M 13 *Herculis* (N.G.C. 6205)	W. E. Wilson
23	Total Solar Eclipse, 1893 April 16 (5 sec.)	J. Kearney
24	Total Solar Eclipse, 1893 April 16 (20 sec.)	J. Kearney
25	The Moon (Age $7^d\ 3^h$)	Lick Observatory
26	The Moon (Age $12^d\ 6\frac{1}{2}^h$)	Lick Observatory
27	The Moon (Age $16^d\ 18^h$)	Lick Observatory
28	The Moon (Age $23^d\ 8^h$)	Lick Observatory

R.A.S. Ref. No.	Subject.	Photographed by
29	The Sun, 1892 February 13	Roy. Obs., Greenwich
30	The Sun, 1892 July 8	Roy. Obs., Greenwich
31	Portion of Moon (Region of Maginus)	Lœwy and Puiseux
32	The Moon (Age 14^d 1^h)	Lick Observatory
33	Portion of Moon (Ptolemæus, &c.)	Lick Observatory
34	Portion of Moon (Mare Serenitatis)	Lick Observatory
35	Portion of Moon (Clavius, Licetus, &c.)	Lick Observatory
36	Portion of Moon (Regiomontanus, &c.)	Lick Observatory
37	Portion of Moon (Tycho, Thebit, &c.)	Lick Observatory
38	Portion of Moon (Theophilus, &c.)	Lick Observatory
39	Total Solar Eclipse, 1896 August 9 (3 sec.)	S. Kostinsky
40	Total Solar Eclipse, 1896 August 9 (26 sec.)	A. Hansky
41	Cluster M 56 *Lyræ* (N.G.C. 6779)	
42	Nebulæ M 81, 82 *Ursæ Majoris* (N.G.C. 3031, 3034)	
43	Cluster M 56 *Lyræ* (enlarged) (N.G.C. 6779)	
44	Solar Corona, 1871 December 12, Baikul	H. Davis
45	Solar Corona, 1875 April 6, Siam	Lockyer and Schuster
46	Solar Corona, 1878 July 29, Wyoming	W. Harkness
47	Solar Corona, 1882 May 17, Egypt	Abney and Schuster
48	Solar Corona, 1883 May 6, Caroline Island	Lawrance and Woods
49	Solar Corona, 1885 September 9, Wellington, N.Z.	Radford
50	Solar Corona, 1886 August 29, Grenada, W.I.	A. Schuster
51	Solar Corona, 1887 August 19, Japan	M. Sugiyama
52	Solar Corona, 1889 January 1, California	W. H. Pickering
53	Solar Corona, 1889 December 22, Cayenne	J. M. Schaeberle
54	Solar Corona, 1893 April 16, Fundium	J. Kearney
55	Solar Corona, 1893 April 16, Brazil	A. Taylor
56	Great Nebula in *Orion*	W. E. Wilson
57	Dumb-bell Nebula, *Vulpecula* (N.G.C. 6853)	W. E. Wilson
58	Spiral Nebula, *Canes Venatici* (N.G.C. 5194)	W. E. Wilson
59	Ditto (enlarged) (N.G.C. 5194)	W. E. Wilson
60	Annular Nebula, *Lyra* (N.G.C. 6720)	W. E. Wilson
61	Meteor Trail and Comet Brooks, 1893 November 13	E. E. Barnard
62	Total Solar Eclipse, 1898 January 22 (5 sec.)	W. H. M. Christie
63	Total Solar Eclipse, 1898 January 22 (20 sec.)	W. H. M. Christie
64	Solar Corona, 1896 August 9, Novaya Zemlya	G. Baden-Powell
65	Solar Corona, 1898 January 22, Pulgaon, India	E. H. Hills
66	Nebula in *Andromeda*	Roy. Obs., Greenwich
67	Spectrum of Sun's limb, 1898 January 22	E. H. Hills

R.A.S. Ref. No.	Subject.	Photographed by
68	Annular Nebula, *Lyra* (N.G.C. 6720)	Lick Observatory
69	Dumb-bell Nebula, *Vulpecula* (N.G.C. 6853)	Lick Observatory
70	Spiral Nebula, *Canes Venatici* (N.G.C. 5194-5)	Lick Observatory
71	Spiral Nebula, *Ursa Major* (N.G.C. 5457)	Lick Observatory
72	Trifid Nebula, *Sagittarius* (N.G.C. 6514)	Lick Observatory
73	Great Nebula in *Orion*	Lick Observatory
74	Cluster M 13 *Herculis* (N.G.C. 6205)	Lick Observatory
75	Solar Surface with Faculæ	G. E. Hale
76	Faculæ and Prominences	G. E. Hale
77	Total Solar Eclipse, 1898 Jan. 22 ($\frac{3}{5}$ sec.)	W. H. M. Christie
78	Nebula H V. 14 *Cygni* (N.G.C. 6992)	W. E. Wilson
79	Portion of Moon (Theophilus, &c.)	Yerkes Observatory
80	Total Solar Eclipse, 1900 May 28 (30 sec.)	E. E. Barnard
81	Comet 1901 I., 1901 May 4	Roy. Obs., Cape of G. H.
82	Comet 1901 I., 1901 May 6	Roy. Obs., Cape of G. H.
83	Comet 1901 I., 1901 May 9	Perth Obs., W. Australia
84	Solar Surface with Faculæ	H. Deslandres
85	Solar Prominences	H. Deslandres
86	Nebula about Nova *Persei*, 1901 September 20	G. W. Ritchey
87	Nebula about Nova *Persei*, 1901 November 13	G. W. Ritchey
88	Total Solar Eclipse, 1901 May 18 (10 sec.)	F. W. Dyson
89	Total Solar Eclipse, 1901 May 18 (40 sec.)	F. W. Dyson
90	Comet *b* 1902 III. (Perrine), 1902 Sept. 29	Roy. Obs., Greenwich
91	Portion of Moon (Mare Serenitatis, &c.)	Yerkes Observatory
92	Portion of Moon (Rough Crater Region, Mare Nubium)	Yerkes Observatory
93	Portion of Moon (Tycho, Theophilus, &c.)	Yerkes Observatory
94	Portion of Moon (Bullialdus to Copernicus)	Yerkes Observatory
95	Portion of Moon (Copernicus)	Yerkes Observatory
96	Great Nebula in *Orion*	Yerkes Observatory
97	Great Nebula in *Orion* (Central portion)	Yerkes Observatory
98	Nebula in *Andromeda*	Yerkes Observatory
99	Nebula in *Cygnus* (N.G.C. 6960)	Yerkes Observatory
100	Nebula in *Cygnus* (N.G.C. 6992)	Yerkes Observatory
101	Cluster M 13 *Herculis* (N.G.C. 6205)	Yerkes Observatory
102	Cluster M 13 *Pegasi* (N.G.C. 7078)	Yerkes Observatory
103	Solar Surface with Faculæ	Yerkes Observatory
104	The Moon, 1900 April 5	P. Puiseux
105	The Moon, 1902 November 13	P. Puiseux
106	The Moon, 1903 February 6	P. Puiseux
107	The Moon, 1903 September 12	P. Puiseux

Nos. 44–55 and Nos. 64 and 65 form a series of corona photographs, oriented and reduced to the same scale.

The above photographs are now on sale to Fellows as prints, either platinotype or aristotype, mounted on sunk cut-out mounts, measuring 12 inches by 10 inches, and also as lantern slides. Nos. 44–55 and Nos. 64 and 65 are also supplied as transparencies, $6\frac{1}{4}$ inches square.

Price of prints, 1*s.* 6*d.* each; lantern slides, 1*s.* each; packing and postage extra.

Unmounted prints, 1*s.* each, can be obtained to order.

Transparencies, $6\frac{1}{4}$ inches square (Nos. 44–55 and Nos. 64 and 65), 3*s.* 6*d.* each.

Orders to be addressed to W. H. Wesley, Burlington House, London, W. In ordering prints or slides the R.A.S. Reference only need be quoted, but in the case of prints it should be stated whether platinotypes or aristotypes are required.

Instruments belonging to the Society.

A brief description of the chief instruments and other particulars relating to them will be found in *Monthly Notices*, vol. xxxvi. p. 126.

No. 1. The *Harrison* clock.
2. The *Owen* portable circles, by Jones.
3. The *Beaufoy* circle.
4. The *Beaufoy* transit instrument.
5. The *Herschel* 7-foot telescope.
6. The *Greig* universal instrument, by Reichenbach and Ertel. The transit telescope, by Utzschneider and Fraunhofer, of Munich.
7. The *Smeaton* equatorial.
8. The *Cavendish* apparatus.
9. The 7-foot Gregorian telescope (late Mr. Shearman's).
10. The variation transit instrument (late Mr. Shearman's).
11. The universal quadrat, by Abraham Sharp.
12. The *Fuller* theodolite.
13. The standard scale, by Troughton and Simms.
14. The *Beaufoy* clock, No. 1.
15. The *Beaufoy* clock, No. 2.
16. The *Wollaston* telescope.
17. The *Lee* circle.
18. The *Sharpe* reflecting circle.
19. The *Brisbane* circle.
20. The *Baker* universal equatorial.
21. The *Reade* transit.
22. The *Matthew* equatorial, by Cooke.

No. 23. The *Matthew* transit instrument.
„ 24. The *South* transit instrument.
„ 25. A sextant, by Bird (formerly belonging to Captain Cook).
„ 26. A globe showing the precession of the equinoxes.

The *Sheepshanks* collection :—

„ 27. (1) 30-inch transit instrument, by Simms, with level and two iron stands.
„ 28. (2) 6-inch transit theodolite, with circles divided on silver; reading microscopes, both for altitude and azimuth; cross and siding levels; magnetic needle; plumb-line; portable clamping foot and tripod stand.
„ 29. (3) Equatorial stand and clock movement for $4\frac{6}{10}$-inch telescope (telescope lost); double-image micrometer; two wire micrometers; object-glass micrometer.
„ 30. (4) $3\frac{1}{4}$-inch achromatic telescope, with equatorial stand; double-image micrometer; one terrestrial and three astronomical eyepieces.
„ 31. (5) $2\frac{3}{4}$-inch achromatic telescope of $28\frac{1}{4}$-inch focal length, with stand; one terrestrial and three astronomical eyepieces.
„ 33. (7) 2-foot navy telescope.
„ 34. (8) Transit instrument of 45 inches focal length, with iron stand and also Y's for fixing to stone piers; two axis levels.
„ 35. (9) Repeating theodolite, by Ertel, with folding tripod stand.
„ 36. (10) 8-inch pillar sextant, by Troughton, divided on platinum, with counterpoise stand and artificial horizon.
„ 37. (11) Portable zenith telescope and stand, $2\frac{3}{4}$-inch aperture and 45 inches focal length; 10-inch horizontal circle and 8-inch vertical circle, reading to 10″ by two verniers to each circle.
„ 38. (12) 18-inch Borda repeating circle, by Troughton, $2\frac{1}{8}$-inch aperture and 24 inches focal length; the circles divided on silver, the horizontal circle being read by four verniers, and the vertical circle by three verniers, each to 10″.
„ 39. (13) 8-inch vertical repeating circle, with diagonal telescope, by Troughton and Simms; circle divided on silver, reading to 10″; a 5-inch circle at eye-end, reading to single minutes; horizontal circle 9 inches diameter in brass to single minutes.
„ 40. (14) A set of surveying instruments, consisting of a 12-inch theodolite for horizontal angles only, reading to 10″; two sets of adjusting plates; tripod stand with enclosed telescope; heavy stand for theodolite; Y-piece of level; two large and three small ground-glass bubbles divided; level collimator, object-glass $1\frac{5}{8}$-inch diameter

and 16 inches focal length; micrometer eyepiece, comb, and wires; mercury bottle and trough.

No. 41. (15) Level collimator, with object-glass $1\frac{7}{8}$-inch diameter and 16 inches focal length; stand, rider-level, and fittings.

„ 42. (16) 10-inch reflecting circle by Troughton, reading by three verniers to 20″; counterpoise stand; artificial horizon, with mercury; two tripod stands.

„ 43. (17) Hassler's reflecting circle, by Troughton, with counterpoise stand.

„ 44. (18) 6-inch reflecting and repeating circle, by Troughton and Simms, contained in three boxes, two of which form stands. Circle divided on silver, reading to single minutes; two inside arcs divided to single degrees, 150 degrees on each side; artificial horizon and mercury.

„ 45. (19) 5-inch reflecting and repeating circle, by Lenoir, of Paris.

„ 46. (20) Reflecting circle, by Jecker, of Paris, 11 inches in diameter, with one vernier reading to 15″.

„ 47. (21) Box sextant; reflecting plane and level.

„ 48. (22) Prismatic compass, by Troughton and Simms.

„ 49. (23) Mountain barometer.

„ 50. (24) Prismatic compass, by Thomas Jones, mounted with a cylindrical lens.

„ 51. (25) Ordinary $4\frac{1}{2}$-inch compass with needle.

„ 52. (26) Dipping needle, by Robinson.

„ 53. (27) Compass needle, mounted for variation.

„ 54. (28) Magnetic intensity needle, by Meyerstein, of Göttingen; a strongly fitted brass box with heavy magnet; filar suspension.

„ 55. (29) Box of magnetic apparatus.

„ 56. (30) Hassler's reflecting circle, by Troughton; a $10\frac{1}{2}$-inch reflecting and repeating circle, with stand and counterpoise, divided on platinum with two movable and two fixed indices; four verniers reading to 10″.

„ 57. (31) Box sextant and glass plane artificial horizon, by Troughton and Simms.

„ 58. (32) Plane $2\frac{3}{8}$-inch speculum, artificial horizon and stand.

„ 59. (33) $2\frac{1}{2}$-inch circular level horizon, by Dollond.

„ 60. (34) Artificial horizon, roof, and trough; the trough $8\frac{1}{4}$ by $4\frac{1}{2}$ inches; tripod stand.

„ 61. (35) Set of drawing instruments, consisting of 6-inch circular protractor and common protractor, T-square; one beam compass.

„ 62. (36) A pantograph.

„ 63. (37) A noddy.

„ 64. (38) A small Galilean telescope with object-glass of rock crystal.

„ 65. (39) Five levels.

No. 66. (40) 18-inch celestial globe.
„ 67. (41) Varley stand for telescope.
„ 69. (43) Telescope, with object-glass of rock crystal.
„ 71. Portable altazimuth tripod.
„ 72. Four polarimeters.
„ 74. Registering spectroscope, with one large prism.
„ 76. Two five-prism direct-vision spectroscopes.
„ 78. $9\frac{1}{4}$-inch silvered-glass reflector and stand, by Browning.
„ 79. Spectroscope.
„ 80. A small box, containing three square-headed Nicol's prisms ; two Babinet's compensators ; two double-image prisms ; three Savarts ; one positive eyepiece, with Nicol's prism ; one dark wedge.
„ 81. A back-staff, or Davis' quadrant.
„ 82. A nocturnal or star dial.
„ 83. An early non-achromatic telescope, of about 3 feet focal length, in oak tube, by Samuel Scatliffe, London.
„ 84. A Hollis observing chair.
„ 85. Double-image micrometer, by Troughton and Simms.
„ 86. $4\frac{1}{2}$-inch Gregorian reflecting telescope, by Short, with altazimuth stand and 6-inch altitude and azimuth circles and two eyepieces.
„ 87. $3\frac{1}{4}$-inch Gregorian reflecting telescope with wooden tripod stand.
„ 88. Pendulum, with 5-foot brass suspension rod, working on knife-edges, by Thomas Jones.
„ 89. A Rhabdological Abacus. A contrivance invented by Mr. H. Goodwyn, consisting of a box filled with compartments, in which are square rods covered with numbers, which can be arranged so as to facilitate the labour of multiplying high numbers.
„ 90. An Arabic celestial globe of bronze, $5\frac{3}{4}$ inches in diameter.
„ 91. Astronomical time watch-case, by Professor Chevallier.
„ 92. 2-foot protractor, with two movable arms, and vernier.
„ 93. Beam compass, in box.
„ 94. 2-foot navigation scale.
„ 95. Stand for testing measures of length.
„ 96. Artificial planet and star, for testing the measurement of a fixed distance at different position-angles.
„ 97. 12-cell Leclanché battery.
„ 98. 2-foot 6-inch navy telescope, with object-glass $2\frac{1}{2}$ inches, by Cooke, with portable wooden tripod stand.
„ 99. 12-inch transit instrument, by Fayrer and Son, with level and portable stand.
„ 100. 9-inch transit instrument, with level and iron stand.
„ 101. Small equatorial sight instrument, by G. Adams, London.
„ 102. Sun-dial, by Troughton.
„ 103. Sun-dial, by Casella.

No. 104. Sun-dial.
„ 105. Box sextant, by Troughton and Simms.
„ 106. Prismatic compass, by Schmalcalder, London.
„ 107. Compass, by C. Earle, Melbourne.
„ 108. Prismatic compass, by Negretti and Zambra.
„ 109. Dipleidoscope, by E. Dent.
„ 110. Abney level, by Elliott.
„ 111. Pocket spectroscope, by Browning.
„ 112. Universal sun-dial.
„ 113. Double sextant, by Jones.
„ 114. Two models, illustrating the effects of circular motions.
„ 115. A cometarium.
„ 117. Two old sun-dials.
„ 118. A $10\frac{1}{2}$-inch sixteenth-century celestial globe, on bronze tripod stand.
„ 119. Specimens of diffraction gratings, by Prof. W. A. Rogers.
„ 120. A 6-prism spectroscope, by Browning.
„ 121. Spitta's improved maximum and minimum thermometer.
„ 122. A 6-inch speculum, with flat; the speculum said to be by Sir W. Herschel, and re-figured by Sir J. Herschel.
„ 123. A 6-inch refracting telescope, by Grubb, with 3 eyepieces.
„ 124. Position micrometer, by Cooke.
„ 125. A 6-inch refracting telescope, by Simms, with eyepieces and solar diagonal.
„ 126. $3\frac{1}{2}$-inch portable refracting telescope, by Tulley, with tripod stand.
„ 127. Globe representing the visible surface of the Moon, by John Russell, R.A. (1797).
„ 128. Bichromate battery and Ruhmkorff coil.
„ 129. Slater's improved armillary sphere.
„ 130. 10-inch brass pillar sextant with counterpoise stand, by Troughton.
„ 131. Double box sextant, by Cary.
„ 132. Equatorially mounted camera with $2\frac{1}{2}$-inch portrait lens and telephotographic enlarging lens by Dallmeyer; iron pillar.
„ 133. $3\frac{1}{4}$-inch equatorial by Ross, with tall tripod stand, equatorial mounting, eyepieces, and micrometer.
„ 134. Old transit instrument, 2-inch aperture and 3 feet focal length (without stand), formerly belonging to Dr. Longfield, of Cork.
„ 135. Globe of Mars, by E. M. Antoniadi.
„ 136. A small universal instrument by W. and S. Jones, London; the telescope $1\frac{1}{2}$-inch aperture and 15 inches focal length. [Presented by Miss Moore.]
„ 137. Polar siderostat by Hilger, with $4\frac{1}{8}$-inch mirrors. [Presented by Mr. Alexr. Foote.]

No. 138. Transit instrument, aperture $2\frac{3}{4}$-inch, with collimator and stand. [Presented by Mrs. Cross.]
„ 139. Transit instrument, aperture $1\frac{1}{2}$-inch, with portable stand. [Presented by Mrs. Cross.]
„ 140. $3\frac{1}{2}$-inch object-glass and tube. [Presented by Mrs. Cross.]
„ 141. 9-inch Newtonian reflector and equatorial stand. [Presented by Mrs. Cross.]

Besides the above, there is the following apparatus available for eclipse work :—

4 Slits for Spectroscope.
Abney doublet lens used in photographing the corona.
2 Dallmeyer negative enlarging lenses.
Cœlostat with 16-inch plane mirror.

The following instruments are lent, during the pleasure of the Council, to the undermentioned persons :—

No. 6. The Greig universal instrument, to Mr. W. Heath.
„ 23. The *Matthew* transit, to Captain W. Noble.
„ 29. (3) Equatorial mounting, clock, &c., to the Rev. C. D. P. Davies.
„ „ Wire micrometer (No. 2), to the Rev. C. D. P. Davies.
„ 30. (4) $3\frac{1}{4}$-inch equatorial and stand, to Mr. M. E. J. Gheury.
„ „ Double-image micrometer, to the Rev. W. J. B. Roome.
„ 31. (15) $2\frac{3}{4}$-inch telescope (object-glass only), to the Rev. C. D. P. Davies.
„ 36. (10) Sextant, stand, &c., to Mr. Stanley Williams.
„ 37. (11) Zenith telescope (object-glass only), to the Rev. C. D. P. Davies.
„ 45. (19) Horizon, roof and mercury bottle, to Mr. Stanley Williams.
„ 69. (43) Telescope with rock-crystal object-glass, to Sir W. Huggins.
„ 98. 2-foot 6-inch navy telescope, to the Rev. J. M. Bacon.
„ 119. Specimens of diffraction gratings, to Dr. Jas. Hunter.
„ 120. 6-prism spectroscope, to Dr. Jas. Hunter.
„ 123. 6-inch telescope, by Grubb (object-glass only), to Mr. W. E. Wilson.
„ 126. $3\frac{1}{2}$-inch portable telescope, by Tulley, to Mr. J. H. Bell.
„ 130. 10-inch pillar sextant, to Mr. F. Robbins.
„ 133. $3\frac{1}{4}$-inch equatorial, by Ross, to Dr. A. W. Roberts.
„ 137. $4\frac{1}{8}$-inch polar siderostat, by Hilger, to Dr. Jas. Hunter.
„ 138. $2\frac{3}{4}$-inch transit and stand, to the Rev. E. Goetz.

No. 139. Transit instrument and stand, to the Rev. C. L. Tweedale.

„ 140. $3\frac{1}{2}$-inch object-glass and tube, to the Rev. C. L. Tweedale.

The Gold Medal.

The Council have awarded the Society's Gold Medal to Professor G. E. Hale for his method of photographing the solar surface and other astronomical work. The President will lay before the Society the grounds upon which the award has been founded.

Publications of the Society.

During the past year vol. lxiii. of the *Monthly Notices* has been issued.

In accordance with the arrangement made with the Royal Society, mentioned in previous Annual Reports, two Appendices to vol. lxiii. of the *Monthly Notices* have been issued.

The following Appendices to the *Memoirs* have also been issued :—

Appendix IV. to vol. liv. Lockyer and Baxendall, The Spectrum of γ *Cygni*.

Appendix V. to vol. liv. Evershed, Solar Eclipse of 1900 May 28.

Appendix I. to vol. lv. Poynting, Radiation in the Solar System.

Vol. liv. of the *Memoirs* will shortly be published.

Obituary.

The Council regret that they have to record the loss by death of the following Fellows and Associate during the past year :—

Fellows :—J. H. Brown.
E. T. Carter.
A. A. Common.
* William Francis.
C. H. Gatty.
James Glaisher.
William Harnett.
W. A. Kibbler.
Samuel Kinns.
Thomas Mackenzie.
A. B. Martin.
F. M. Newton.
W. I. Page.
F. C. Penrose.
Lord Pirbright.
Harold Seward.
Washington Teasdale.
Major-Gen. W. H. Wardell.
W. L. Watson.
Associate :—Proser Henry.

John Henry Brown was born at Woolwich on the 4th of September 1836. His father was a dentist, who practised at Woolwich and afterwards at Brighton. From childhood he was fond of scientific pursuits, and while at school made himself a photographic camera. He became a dentist and joined his father in practice in the Old Steyn, Brighton. Later he moved to Hove, where he continued to practise till seven or eight years ago, when he retired.

He was a clever mechanician, and about 1867 invented the now well known Iris Diaphragm. He refused to patent this invention, preferring to publish it at once for the free use of all. He possessed a small telescope, of which he made constant use. He became a Fellow of the Society on the 10th of February 1888.

Mr. Brown married in 1883, and leaves a widow and two

* Although Dr. Francis died subsequently to 1903 December 31 an account of his life is given in this year's Report.

step-children. His death took place at his residence at Brighton on the 19th of December 1903. [For these particulars the Council are indebted to Mr. Arthur F. Griffith.]

Edward Tremlett Carter was born in Calcutta in 1866. He was the eldest of ten surviving children. Brought to England at an early age, he was privately educated at Bristol, and later at the Merchant Venturers' College in that city and at Bristol University College.

Completing his studies in physics and engineering under Professor Hele Shaw and Professor Silvanus P. Thompson, Mr. Carter remained for a short time at the College as demonstrator, until he obtained an appointment at the School of Electrical Engineering and Submarine Telegraphy, Hanover Square, W., first as assistant to the late Mr. Lant Carpenter and afterwards as a lecturer at the school. Concurrently with this appointment he practised as a consulting engineer, and was a frequent contributor to the technical press. On the closing of the School of Electrical Engineering in 1893 he joined the permanent staff of the *Electrician* under Mr. Trotter, who was then editor, and upon whose retirement in 1895 Mr. Carter was appointed assistant editor under Mr. W. G. Bond. In 1897 Mr. Carter went over to Montreal as representative of the *Electrician* at the meeting of the British Association there, and made also an extended tour in America on behalf of the paper. Returning to England, he soon after succeeded Mr. Bond as editor-in-chief of the *Electrician*.

He was to a small extent an author of fiction as well as a writer on engineering subjects. His chief work in book form was *Motive Power and Gearing for Electrical Machinery*.

He had a delicate constitution, and in the winter of 1899, after a severe attack of pleurisy and bronchitis following upon influenza, he was obliged to give up work. A tour in the Mediterranean and Egypt did him good, but the improvement was not a permanent one, and in October 1902 it was discovered that his lungs were seriously affected. He underwent the open-air treatment for some time, with, however, no useful result, and died on the 16th of April at Clevedon, Somerset, where he had been devotedly nursed by his wife after it had been found that the sanatorium treatment was of no avail.

Mr. Carter interested himself deeply in astronomy, more especially in astrophysics and the bearing of astronomical phenomena and history on the evolution theory of the universe.

Mr. Carter was a member of the Institution of Electrical Engineers and of the Société des Ingénieurs Civils de France, and of the Physical Society of London. He became a Fellow of this Society on the 9th of January 1891. He leaves a widow and three sons.

[The Council are indebted to Mr. G. Thomas-Davies for this notice.]

Andrew Ainslie Common was born at Newcastle-on-Tyne on the 7th of August 1841. He was the son of Thomas Common, a well-known surgeon of the north, who gained celebrity by his treatment of cataract. The family is of Scottish border stock and came originally from Dumfriesshire, and the name Common is one of the many variants of Comyn.

While Dr. Common was still in infancy his father died, and the means of the family were straitened by pecuniary misfortunes. In consequence he had to go into the world to seek his living at an early age. He owed his attainments and position entirely to his own character and energy. He had to rely on himself, and no friend advised him in his course of study; it may be that these were contributory causes to the freshness and freedom from prejudice he brought to bear on his work.

He married in 1867, a few years after his association with his uncle in the firm of Matthew Hall & Co., of London, sanitary engineers, a firm which he conducted with success till 1890, when he practically retired from business.

Before he was ten years old he showed a constant interest in a telescope his mother borrowed for him from Dr. Bates, of Morpeth, but he had no opportunity for some years of following his inclination towards astronomical studies. In 1874 he set up in London a $5\frac{1}{2}$-inch refractor mounted equatorially, and made with it his first attempts at astronomical photography. Two years later he became a Fellow of the Royal Astronomical Society. About the same time he moved to Ealing, where he lived till his death in 1903.

He decided to improve his instrumental equipment, and obtained two glass discs of 17 inches diameter, with the intention of grinding a mirror and mounting a reflecting telescope. He, however, abandoned this idea and ordered an 18-inch silvered glass reflector from Calver. The mounting he designed and carried out himself. He commenced with this instrument, which was at the time a powerful one, in 1877, and in January 1878 he communicated to the Astronomical Society observations of the outer satellite of *Mars* and of the satellites of *Saturn*.

He was alive to the possibilities of photography in astronomy, and possibly the comparative slowness of the plates of that time was one reason which led him to obtain a larger reflector and to devote so much care to its mounting. In the *Monthly Notices* of April 1879 he has a "Note on Large Telescopes, with Suggestions for Mounting Reflectors." He carried these into practice shortly afterwards by obtaining a 36-inch mirror from Calver and mounting it in accordance with his own ideas. Particulars of the mounting are given in vol. xlvi. of the *Memoirs*. The mounting, which was a departure from recognised forms, showed great engineering skill, and particular attention may be drawn to the relief of the friction of the polar axis by partly floating it in mercury, and

to the plan projected but not carried out of electric control by the sidereal clock for very prolonged photographic exposures.

With the 3-foot reflector Dr. Common made visual observations of the satellites of *Mars* and *Saturn*, and the nebulæ in the *Pleiades*. He also obtained a photograph of Comet *b* 1881 on the 24th of June 1881, on the same night that it was photographed by Draper in America, the earliest successful photographs of a comet.

But Dr. Common's energy was mainly devoted to the photography of the *Orion* Nebula. His first attempt was on the 20th of January 1880, and was a total failure, but he patiently improved the driving of his clock and took advantage of each increase of sensitiveness in photographic plates till on the 17th of March 1882 he obtained a photograph "which excited the admiration of all the astronomers who had an opportunity of inspecting it." *

He still further perfected the guiding of his telescope, and obtained on the 30th of January 1883, with an exposure of 37 minutes, the splendid photograph with which all astronomers are familiar. Of the merits of this photograph he modestly remarked: "Although some of the finer details are lost in the enlargement, sufficient remains to show that we are approaching a time when photography will give us the means of recording, in its own inimitable way, the shape of a nebula and the relative brightness of the different parts in a better manner than the most careful hand-drawings."

The Gold Medal of the Society was awarded to him in 1884 for the great success which had attended his efforts in celestial photography.

Shortly after this Dr. Common sold his 3-foot telescope to Mr. Edward Crossley, of Halifax, who presented it later to the Lick Observatory. He took a year's rest from astronomy before commencing the great work of his life, the construction of his 5-foot reflector. Into this he put his whole heart, and devoted months and years of patient labour to the difficult task he had set himself. In the construction of his large mirror he had to face a number of unexpected problems and to put up with wearying disappointments. He overcame the difficulties by accurate observation of the effect of tiny and apparently quite trivial details, and by his perseverance in correcting and improving his work by the experience he gained. The Council reports of his Observatory for the years 1887–1892 are interesting records of his progress.

In February 1887 he reports that the year has been entirely devoted to the construction of the 5-foot reflector. The machine for grinding was completed in September 1886, and great progress made with the mirror. Permanent photographic records of the progressive state of the surface were obtained by

* Address by the President (E. J. Stone) on presenting the Gold Medal, *Monthly Notices*, vol. xliv. p. 211.

Foucault's test. The heavy work of the mounting was in hand. By February 1888 the mirror had been polished and figured several times. Evidence of internal strain in the glass was found, and, as it was uncertain to what extent this would affect the image, he contemplated ordering another disc. The mounting was in a forward state, the telescope tube being connected to the polar axis, which was a wrought-iron cylinder of 8 feet diameter, floating in a tank of water to relieve the friction. The reflector was practically completed in September 1888, and was ready for use in February 1889, but a slight ellipticity was found in the star images. It was accordingly refigured and resilvered in the spring of that year; the images were much improved, but at the same time a new disc was ordered. Between March 1890 and February 1891 the telescope was used on every available night, but, owing to unfavourable weather, very few nights were suitable for photography of nebulæ. Photographs of the *Orion*, *Dumb-bell*, *Pleiades*, and other nebulæ were obtained. The new 5-foot disc had been received, and such skill had Dr. Common acquired that while "it took two years of worry and anxiety to make the first mirror, the second disc was made into an almost perfect mirror in three months from the time it was first put on the machine."* A detailed account, full of interest, is given in the *Memoirs*, vol. l., "On the Construction of a Five-foot Equatorial Reflecting Telescope." This paper contains a description of the grinding machine, the manufacture of the tools for grinding and polishing, the methods of figuring and testing, of silvering, and of supporting the mirror, and of the equatorial mounting of the telescope. Of the performance of the 5-foot he says at the close of his paper: "As far as I am able to judge from the use of other mirrors of considerable size the gain has been maintained, and the power of the 5-foot over the 18-inch and the 3-foot is proportionate to the size. On nebulæ this is seen to great advantage, both visually and photographically. Such an object as *Mimas*, which the 18-inch would, under the most favourable circumstances, just render visible and the 3-foot show fairly well, can with the 5-foot be seen close to the end of the ring, and away from it could not be overlooked." The pleasure he derived from the construction of his mirror may be gathered from a sentence in his address when chairman of the Astronomical Section of the British Association in 1900: "The invention of the telescope is to me the most beautiful ever made. Familiarity both in making and in using has only increased my admiration."

Owing to various causes very little use was made of the telescope. A few excellent experimental photographs were taken. One night, while using the instrument as a Newtonian

* The actual time of work was from the 25th of March 1891 to the 24th of June. The machine was in use for 273½ hours, and at 25 strokes a minute this gives 410,250 strokes to make a flat disc into a nearly perfect mirror.—*Memoirs*, vol. l. p. 147.

reflector, he narrowly escaped a fall from the high staging. This decided him to devise, if possible, means of working the telescope from the eye end. The difficulty and risk of boring a hole in the centre of the 5-foot led him to attempt a modification of Cassegrain's form, the second mirror being inclined, so that the image should be clear of the large mirror, but the results, though promising at first, were not satisfactory. No further observations were made with the instrument, as Dr. Common's energies were about this time diverted to new problems in connection with gun-sights and telescopes for the army and navy. In this field his great knowledge of optics and practical skill were happily combined and very successful results obtained, to the great benefit of the country. He was engaged in this work to the time of his death. As regards its national importance the following words of Captain Percy Scott, R.N., spoken at a dinner at the Savage Club on 22nd of November 1902, may be put on record here. He said "that the nation owed a deep debt of gratitude to Dr. Common for the great improvements that he had made in gun-sights. It mattered not how good the gun was, nor how good a man there was behind it; unless the sight was perfect good firing could not be made. The great stride by the British Navy lately in that direction was entirely due to Dr. Common. . . . He had produced a telescope gun-sight which would, when properly used, quadruple the fighting efficiency of our battle-ships."

In the manufacture of this 5-foot reflector Common acquired so intimate an acquaintance with the mechanical properties of glass that the grinding and figuring of smaller mirrors became a matter of ease. In connection with the peculiar difficulties of constructing flat mirrors he devised a specially sensitive form of spherometer. He was extremely generous both with his time and money, and when a mirror was wanted for astronomical work Dr. Common invariably undertook to supply one. For the eclipse of 1889 he made two mirrors of 20 inches aperture and 4·5 inches focus, presenting them to the Royal Society. He made a 30-inch mirror for the Solar Physics Observatory. When Sir Henry Thompson presented an equatorial to the Royal Observatory Dr. Common generously supervised the construction of the 30-inch mirror carried on one side of the declination axis. In 1900 he presented a beautiful flat mirror of 20 inches to the National Physical Laboratory.

The 16-inch cœlostats which Dr. Common designed and made for the Eclipse Expeditions of 1896 bear witness to his mechanical as well as to his optical skill. Attention was directed by M. Lippmann to the fact that there would be no movement in the sky reflected by a mirror which turned at half the Earth's rate about an axis parallel to itself and passing through the pole. The advantages of this arrangement for eclipse photography were further enforced in England by Dr. Stoney and Professor Turner. Dr. Common immediately offered to make such an instrument and

have it tried. The beautiful instrument in which he embodied what was till then merely an interesting geometrical property seems now almost indispensable for eclipse work.

The interest he took in developing new forms of astronomical instruments may be illustrated by the Sheepshanks telescope of the Cambridge University, to which he presented a 16-inch flat mirror, in order that the polar siderostat form of instrument might be tried. The Durham Almucantar is another instrument in which the design was largely indebted to the engineering skill of Dr. Common, whose assistance was gratefully acknowledged by Professor Sampson.

He attended the conferences at which the Astrographic Chart was organised, and though he had shown what could be done with reflectors he unhesitatingly recognised the advantages possessed by refractors for this work, and had great admiration for the beautiful results attained by the brothers Henry. At the conference of 1887 he and M. Janssen were appointed a committee for dealing with astronomical photography outside the work of the Chart.

He was interested in eclipse work, and allowed his observer, Mr. Taylor, to go to the eclipse of December 1889 rather than have a station unoccupied, though Mr. Taylor's assistance had only just been obtained for help with the new 5-foot mirror. He himself went to Norway in 1896 to observe the eclipse of that year, but had cloudy weather.

He joined the Society in 1876, and was elected on the Council in 1879. He received the Gold Medal in 1884. He was treasurer of the Society from 1884 to 1895, and President in 1895 and 1896. He was elected a Fellow of the Royal Society in 1885, and served on its Council from 1893 to 1895. From 1894 he was one of the representatives of the Royal Society on the Board of Visitors of the Royal Observatory, Greenwich. In 1891 the honorary degree of LL.D. was conferred on him by the University of St. Andrew's. In 1900 he was chairman of the Section of Astronomy at the British Association, when he delivered an address on the development of astronomical instruments and the application of photography to astronomy.

He died suddenly on 2nd of June 1903, from heart failure, while at work in his study. He leaves a widow, one son, and three daughters.

The energy he threw into his work and the pleasure his successful results gave him have been already referred to. There was in his character an absence of self-seeking and a disposition to work for the general good of astronomy. He had his reward in the esteem and regard of his fellow astronomers.

F. W. D.

[The Council are indebted to Mr. Drower for some particulars of Dr. Common's life, and also to a notice published by the Royal Society.]

William Francis was born in London in February 1817. He was educated partly at University College School, but chiefly in France and Germany, at St. Omer, Cravelt, and Gera. He studied at University College, London; then proceeded to the University of Berlin, and afterwards to Giessen, where he took his degree of Doctor of Philosophy in 1842. His long residence and frequent travels abroad enabled him to acquire an accurate knowledge of French and German, and brought him into relations with many of the leading men of science on the Continent.

In 1842 he established the *Chemical Gazette*, which he edited until the end of 1859, when it was merged in the *Chemical News*. By means of this publication and by the abstracts and translations which he for many years contributed to the *Philosophical Magazine* he did good service in making known in England the work of Continental chemists. He published in *Taylor's Scientific Memoirs* translations of important foreign papers, including Ohm's *Die galvanische Kette mathematisch bearbeitet*, and Helmholtz's treatise *Die Erhaltung der Kraft*. From 1851 until his death he was one of the editors of the *Philosophical Magazine*, and from 1859 of the *Annals and Magazine of Natural History*. His wide acquaintance with different branches of science, as well as with leading scientific men in England and abroad, made him well fitted for these functions, and the sound judgment with which he discharged them is well known.

Dr. Francis was an original member of the Chemical Society, of which he was elected an Associate in 1841, and soon afterwards a Fellow. He was elected a Fellow of the Linnean Society in 1844, and of the Royal Astronomical Society in 1851, being with one exception the oldest surviving Fellow of the latter Society. He was also an original member of the Physical Society. For a great part of his life he was actively engaged in business in the firm of Taylor and Francis, printers and publishers, of which he had been a partner since 1852.

Dr. Francis married in 1862 Miss Isabella Gray Taunton, by whom he had two sons and six daughters, all of whom survive him. He died at his residence, the Manor House, Richmond, on the 18th of January 1904.

Dr. C. H. Gatty was born at Crowhurst, in Sussex, on the 6th of March 1836, and was the younger son of Mr. George Gatty, who was a taxing master in Chancery. A keen sportsman and typical English country gentleman, Mr. George Gatty acquired the Felbridge property, one of the finest sporting estates in the neighbourhood, with its beautiful park and surroundings, by purchase from the late Lord Liverpool; and on the premature death of his elder brother Mr. C. H. Gatty became heir to the property. He was educated at Trinity College, Cambridge, and possessed very different tastes from those of either his father or his brother, giving up his whole time to scientific and literary study. St. Andrew's University conferred the

degree of LL.D. upon him in recognition of services he rendered to it, and he was also a Fellow of the Royal Society of Edinburgh. After the death of his father, in 1864, he lived with his mother at Felbridge, until she died in 1876, and subsequently his life became akin to that of a recluse and almost a hermit. Like his father he was most munificent in his contributions to anything and everything for the public benefit or advantage. The present Felbridge Church was built by the elder Mr. Gatty, and possesses the remarkable peculiarity of standing in the two Surrey parishes of Godstone and Tandridge, within a quarter of a mile of the Sussex border. Dr. Gatty was chairman of the East Grinstead bench of magistrates in Sussex, and for years attended the bench at Godstone, in Surrey, of which county he was also a justice of the peace. He had no near relations and very few intimate friends, leading, as has been said, the life of a recluse and shutting himself up with his fine and valuable library and instruments. He possessed an elaborate and probably almost unique orrery.

He was elected a Fellow of the Society on the 13th of May 1870, and was at one time a regular attendant at our meetings, but never contributed any paper. His scientific interests were largely divided between astronomy and botany. He died at Felbridge on the 12th of December 1903.

W. N.

James Glaisher, although in early life attached to astronomical pursuits, will be hereafter remembered principally as a meteorologist, not only as having for so many years held the position of Superintendent of the Magnetical and Meteorological Department at the Royal Observatory, Greenwich, but also, in a great degree, on account of his independent work in many directions in the cause of meteorological science. A pioneer in meteorology, he very early turned his attention to the organisation of the many amateur meteorological observers dispersed throughout the country, who, hitherto working in an isolated manner, and too often with inferior instruments, became by his vigorous action federated, as it were, into a system having a common object, thus making it possible, with improved instruments and methods, to produce a reliable body of information on the meteorology of the country—an early type of the more extended international systems that became in after years established. He was also largely instrumental in founding the British Meteorological Society, now known as the Royal Meteorological Society, in the early years of which it was by his own personal exertions that the Society was placed on that secure and stable footing the fruits of which the existing Society now enjoys.

It may be convenient, in the first instance, to speak of his astronomical work. Born on the 7th of April 1809 at Rotherhithe, London, Mr. Glaisher was first heard of as receiving

instruction in the use of astronomical instruments at the Royal Observatory, Greenwich, in the year 1829, in which year he was appointed an assistant upon the Grand Triangulation of the Ordnance Survey of Ireland. He was engaged upon this work, in which he took the keenest interest, for two years, but was then disabled by a very serious illness, brought on by exposure on the mountains, and was obliged to leave the Survey in consequence. On his recovery he became an assistant at the Cambridge Observatory, then under the direction of Professor Airy. A large mural circle, provided for this Observatory, having been mounted in October 1832, and divided on its own pier by Mr. Simms in November, Mr. Glaisher commenced work with this instrument on the 9th of January 1833, the observations during this and the two following years being nearly entirely made by him. A fine series of equatorial observations of Halley's Comet, extending from the 2nd of September 1835 to the 16th of January 1836, was also his work. After the then Professor Airy had taken up the position of Astronomer Royal at Greenwich Mr. Glaisher, who had meanwhile been appointed assistant at Greenwich, was allowed leave of absence to remain for a time at Cambridge, entrusted in a great degree with the task of clearing up the 1835 work. He joined the staff of assistants at Greenwich about the middle of the month of February 1836. Since the year 1834 Mr. Glaisher had been employed, first at Cambridge and afterwards for a time at Greenwich, on the "Reduction of the Greenwich Observations of Planets from 1750 to 1830," but for this work a special staff of computers at Greenwich was soon afterwards formed. He became further employed on the reduction of the Cambridge observations of the Sun, Moon, and planets, and also in the collection of the Cambridge annual results of star places for the formation of the Cambridge Catalogue of 726 stars, reduced to the 1st of January 1830. The Rev. R. Main, then First Assistant at Greenwich, having commenced an investigation into the correction of the elements of the orbit of the planet *Venus*, employing the Cambridge observations of 1833 to 1835 and the Greenwich observations of 1836, had written two papers thereon, but not having time to pursue the subject this work was continued by Mr. Glaisher in two further papers, extending the investigation to include also the Greenwich observations of 1837 to 1839. These papers, under the title "Continuation of the Investigation for the Correction of the Elements of the Orbit of *Venus*," were read before the Royal Astronomical Society on the 12th of June 1840 and the 12th of March 1841 respectively. In April 1858 he communicated to the Society a paper on the observation of the annular solar eclipse of the 14th–15th of March of that year, made near Oundle, Northamptonshire, including observations by other observers; and at the meeting of April 1863 one on "Lines in the Solar Spectrum as observed in the Balloon Ascent of the 31st of March." And at the meeting of

December 1865 he gave an account of "The November Meteoric Shower" of that year, when a considerable number of meteors were seen, but the celebrated display occurred in the following year, 1866.

The Astronomer Royal, in his report to the Board of Visitors in 1836, referred to the proposed construction of a magnetic observatory at Greenwich, and the building was erected at the beginning of the year 1838. The instrumental equipment was sufficiently advanced to allow observations of magnetic declination to be made on one day in each of the months of February, May, August, and November of the years 1839 and 1840 at each fifth minute throughout the twenty-four hours. But in the latter part of the year 1840 the magnetical and meteorological observatory became fully constituted, the Astronomer Royal giving the position of superintendent to Mr. Glaisher, who at once applied himself energetically to the duties of his new post. The first intention had been to carry on the observatory for three years, a period that was afterwards extended to five years, as for the various colonial observatories at that time temporarily established. Finally the observatory was made permanent. Observations of the magnetical and meteorological instruments were made at intervals of two hours, day and night, unless abnormal change or movement was remarked, when extra eye observations, involving much labour, were taken. On the 25th of September 1841 there occurred a remarkable magnetic storm, which, well observed, revealed a new class of magnetic phenomena. An account of this storm being printed and circulated, it was found that at such distant places as Toronto, Trevandrum, and the Cape of Good Hope disturbances of similar character had occurred on the same day, appearing also to have commenced at Toronto "nearly at the same absolute time as at Greenwich." Again on the 24th of September 1847 there occurred another very remarkable magnetic storm, also well observed, "to which there had been nothing comparable before." But from the year 1848 the labour of taking at such times long series of eye observations became unnecessary, since the variations of the principal magnetic and meteorological instruments were afterwards recorded by photography, on a plan arranged by Mr. Charles Brooke, the continuous registration thus obtained giving an insight into the character of the instrumental changes, especially those of the magnets, that has been of the greatest value. It became thus possible to diminish the number of eye observations and avoid so much work at night.

As soon as the duties of his new position permitted Mr. Glaisher undertook an important investigation, that of the question of radiation from the earth at night, and with the assistance of the members of his staff he carried out an extensive series of observations on this interesting branch of meteorological research, employing for the purpose a large number of specially constructed, accurate and very sensitive thermometers, having their scales

engraved on the tube. The observations extended from September 1843 to May 1844. They were very numerous, and the results were incorporated in a paper "On the Amount of the Radiation of Heat at Night from the Earth, and from Various Bodies placed on or near the Surface of the Earth," communicated to, and read before, the Royal Society on the 4th of February 1847. In the course of these experiments he frequently passed the night in the open air, watching for the formation of the dew, and lying on the damp grass. This produced a severe attack of rheumatism, from which he did not recover for several years.

In another paper Mr. Glaisher collected the two-hourly meteorological observations of the barometer and thermometer made at Greenwich during the five years ending 1845, employing them to form, for each month of the year, corrections applicable to observations taken at any hour to obtain mean values, for pressure of the atmosphere, temperature of the air, and the various meteorological elements depending thereon. As regards temperature of the air, corrections obtained from this paper were employed to reduce to mean values the observations of temperature made at the apartments of the Royal Society. The results were contained in two papers, the second of which gave monthly temperatures of the air reduced to Greenwich, from 1771 to 1849, in all of which years, excepting from 1781 to 1786 and from 1844 to 1849, the results depended on the Royal Society records. The three papers here described were communicated to the Royal Society in the years 1848, 1849, and 1850 respectively.

For many years Mr. Glaisher communicated to the Registrar-General of Marriages, Births, and Deaths a quarterly report on the meteorology of the kingdom. This work had an origin in part accidental. Mr. Glaisher, having remarked that the Registrar-General had published the mean temperature of York as being five degrees higher than that of London, wrote to point out to him that this was a physical impossibility, when it appeared that there was no person in the office of the Registrar-General who understood matters of the kind. Mr. Glaisher, in his endeavour to bring into general use instruments of more perfect character than had been hitherto used, was at this time in correspondence with a large number of observers, and persuaded them to report their observations regularly to him, which, reduced on a uniform plan, formed the basis of the report which he commenced about the year 1846 (the writer of this being at that time one of the contributors) to supply quarterly to the Registrar-General with his own special "Remarks on the Weather during the Quarter." His hygrometrical tables, adapted to the use of the dry and wet bulb thermometer, published in 1847, have proved of great service to meteorologists. Many successive editions of these tables have been published, and they have been incorporated in foreign collections of meteorological tables.

The increasing attention that became paid to meteorological science suggested the desirability of forming a society which

should bring into closer union the meteorological workers of our country, by affording them means for the publication of meteorological observations and results, or papers of general meteorological interest, and in the year 1850 Mr. Glaisher, in conjunction with a few others similarly interested, founded the British Meteorological Society, afterwards known as the Meteorological Society, and later as the Royal Meteorological Society. He further undertook the post (so important in a new society) of secretary, a position which he occupied for some twenty years, with the result that, at the time of retiring therefrom, the society had become well established.

At the Great Exhibition of 1851 Mr. Glaisher was appointed Reporter to the Section of Philosophical Instruments, Class X., and produced an able and comprehensive report. Of astronomical instruments there was apparently not a large collection, but one was an interesting exhibit, the historical Westbury Circle made by Troughton at the beginning of the last century for Mr. Pond, afterwards Astronomer Royal. The two circles, it may be remarked, took nearly twelve weeks to graduate, working each week day on an average of eight hours daily, an operation at the present day a question of hours only. Of thermometers only Mr. Simms and Messrs. Negretti and Zambra in the British portion of the exhibition showed instruments graduated on the stem.

The following detached sentences extracted from a lecture given by Mr. Glaisher at the Society of Arts in 1852 (one of a series of lectures on the Great Exhibition) well show what had been the condition of matters, and the efforts that he was making to improve meteorological instruments and methods :—

"The collection of meteorological instruments in the exhibition would lead us to the conclusion that the conditions of good instruments are better understood and fulfilled by makers abroad than at home. That this will speedily cease to be the case I feel assured. . . . That the want of good instruments is experienced I can myself testify. For years I have pursued the subject of meteorology, and have long been convinced that a widely spread and universal system of simultaneous observation, uniformly reduced, must be the groundwork of its establishment as a science. For the sake of this I six years ago reduced my system to practice, and introducing it first among the meteorological observers, contributors to the reports of the Registrar-General, in a short time perceived with satisfaction some of the good results. . . . I have been gradually increasing the number of observers, and have now established upwards of fifty meteorological stations in different parts of the country, all of which contribute observations made and reduced upon my system. . . . I now come to that which had nearly caused the subversion of my scheme, the difficulty of obtaining good instruments at a fair and moderate price. . . . That I have been enabled to do. . . . All the barometers, and the greater part of the thermometers,

scattered among the observers have been made under my direction by him [Mr. Barrow], and constitute, with few exceptions, the most efficient instruments at their command."

In a paper by Mr. Glaisher "On the Severe Weather at the Beginning of the Year 1855, and on Snow and Snow Crystals," published in the *Proceedings of the British Meteorological Society*, he states that the primary figure or base of each crystal appeared to be "a star of six radii, or a hexagon of laminæ, and the compound varieties to include combinations of spiculæ, prisms, cubes, and rhomboids, aggregated upon and around the central figure." There are detailed descriptions of many of the forms of crystals, and also appended are 151 pictures of the different varieties of crystals, from drawings by Mrs. Glaisher based on his sketches. A further paper "On the Meteorological and Physical Effects of the Solar [Annular] Eclipse of the 15th of March 1858" contains meteorological observations made at very frequent intervals during the eclipse, at twenty-nine different stations, with remarks on the effects produced on birds and animals.

Papers on meteorological subjects become henceforward very numerous, amongst which may be found reports on meteorology, including one in relation to the health of the troops in India, discussions of collected observations of meteorological elements, as well as communications on special atmospheric phenomena. In one paper "On the Secular Increase of Mean Temperature" (*Proceedings of the British Meteorological Society*, 1865) Mr. Glaisher concluded from comparison with earlier records, instrumental and otherwise, that our climate during the preceding 100 years had altered, that the temperature of the year was 2° warmer, the winter months all much warmer, and every month of the year somewhat warmer than before. But the last sixty years show no definite change, and it might be desirable to rediscuss the older observations.

Another considerable and important work has yet to be spoken of. the balloon ascents undertaken for scientific purposes. A committee of the British Association having been appointed to consider the question of making observations in the higher strata of the atmosphere, after some preliminary trials with an insufficient balloon, Mr. Glaisher himself undertook to make the necessary ascents, with the aid of the aeronaut Mr. Henry Coxwell, in a large balloon made by the latter at his own cost for this special purpose. The observations proposed to be made were those of atmospheric pressure, temperature, and the hygrometric state of the atmosphere, the height and motions of clouds, and other phenomena. The first ascent was made on the 17th of July 1862, and the last on the 26th of May 1866, in all twenty-eight, some of them in the evening. On five occasions an altitude of between 10,000 and 20,000 feet was reached; on five occasions also an altitude of between 20,000 and 30,000 feet; and on one occasion (the 5th of September 1862) an altitude of 37,300 feet is said to have been reached, a pheno-

menal height, the experiences and sensations of the voyagers at which altitude are narrated in the article on "Aeronautics" in the *Encyclopædia Britannica*. It appeared as one of the results of the experiments that the rate of decrease of temperature with elevation near the earth was very different when the sky was clear from that when it was cloudy, and the equality of temperature at sunset and increase with height after sunset were remarkable facts that were not anticipated. Complete accounts of the observations made in these ascents are to be found in the volumes of the *British Association Reports* between the years 1862 and 1866. Other ascents were afterwards made at Chelsea in a captive balloon on the offer of the owner, M. Giffard, for the purpose of making further observations at low altitudes.

Mr. Glaisher retired from his position at the Royal Observatory at the end of the year 1874, but he continued to lead an active life, still communicating to the Registrar-General his quarterly weather report, one of his early organisations, which indeed he continued to supply until 1901—that is, altogether for a period of some fifty-five years. He took great interest in the Palestine Exploration work, and was chairman of the Executive Committee from 1880 almost up to the time of his death. He discussed observations of atmospheric pressure, temperature, wind, rain, and cloud at points in Palestine in fifteen papers communicated between the years 1891 and 1902 to the publications of the Palestine Exploration Fund.

Another important work that occupied a considerable part of the leisure time of Mr. Glaisher was the calculation of certain factor tables. The Committee of the British Association on Mathematical Tables, of which both Mr. Glaisher and his son Dr. J. W. L. Glaisher were members, in considering the question of factor tables, found that although Burckhardt had calculated tables giving the least factor of all numbers not divisible by 2, 3, or 5 for the first, second, and third millions, and for a small part of the fourth million, and that Dase and Rosenberg had calculated similar factors for the seventh, eighth, and ninth millions, there thus remained three intermediate millions for which factors were yet required. Crelle, previous to 1850, had presented to the Berlin Academy the manuscript of factor tables for the intervening fourth, fifth, and sixth millions, but on inquiry being afterwards made as to whether there were any chance of publication of the manuscript, the Secretary of the Physical and Mathematical Section of the Academy reported that the manuscript had been examined on a former occasion and found to be so inaccurate that "the Academy was convinced that the publication would never be advisable." The Committee of the British Association, considering, however, that the completion of the factor tables for these three millions was a matter of great importance, made a grant of 250*l.* towards the cost of doing the work, which, being one that required careful supervision,

was undertaken by Mr. Glaisher with the assistance of two computers, the results for these fourth, fifth, and sixth millions, with an explanatory introduction by Mr. Glaisher, being published (by Taylor and Francis) in three separate quarto volumes.

Mr. Glaisher was elected a Fellow of the Royal Society in the year 1849, and previously, in the year 1841, had been elected a Fellow of the Royal Astronomical Society, and at the time of his death was its oldest Fellow. Of the Royal Meteorological Society he was, as before mentioned, mainly its founder. He was connected also with many other scientific societies—the Royal Microscopical (of which he was President in 1865–68), the Photographic (of which he was President for the twenty-three years 1869–92), and others—and he served on various British Association Committees, being for many years a member of that on Luminous Meteors. In various industrial undertakings he took a lively interest to the end of his life. After his retirement from the Royal Observatory he continued to reside for a number of years at Blackheath, but eventually he removed to Croydon, where after a very active life he died at "The Shola," on the 7th of February 1903, in the 94th year of his age. He was buried at Shirley, near Croydon. W. E.

William Harnett was born at Tralee, co. Kerry, on the 26th of March 1830. He was educated at Oscott College, Warwickshire, and was for some time a corn broker in Liverpool.

Several years ago he retired from business and went to live at Wimbledon. He died on the 2nd of January 1903, leaving a widow, one son, and three daughters.

Mr. Harnett had long been interested in astronomy, though he only recently became a Fellow of the Society, being elected on the 11th of January 1895.

W. Ambrose Kibbler was born in 1848 at Hackney, where his father long practised as a doctor. The son was a student at the London Hospital, where he afterwards held for a short time the posts of house surgeon and house physician. In 1876 he took the degree of M.B. at Marshall College, Aberdeen. He joined his father at Hackney and continued to practise there till the end of his life. During the last few years Dr. Kibbler experimented with X-rays in cases of cancer. Though no permanent cure was effected he was able to alleviate suffering to some extent by this treatment.

Besides being a skilful physician Dr. Kibbler was an artist of considerable merit. He was a member of the Langham Sketching Club, and had several pictures hung at the Institute of British Artists. For many years he was an enthusiastic astronomical observer. About eighteen years ago he commenced observations of the Moon with a $9\frac{1}{4}$-inch reflector. Some trouble with his eyes obliged him to discontinue this work

for a time. About five years ago he obtained a $12\frac{1}{2}$-inch reflector and made observations of *Jupiter*, *Mars*, and *Saturn*. His artistic talent enabled him to make good drawings at the telescope. At the time of his death he had been a Fellow of the Society for little more than a year, having been elected on the 14th of February 1902. Dr. Kibbler married in 1879 and leaves two sons. He died on the 10th of September 1903.

Samuel Kinns was born on the 14th of November 1826, at Colchester, where his father, the Rev. John Osborne Kinns, was a Congregational minister. He obtained the degree of Ph.D. from the University of Jena in 1859, and was elected a Fellow of the Royal Astronomical Society in the same year. For about a quarter of a century he was principal of a school, called "The College," at Highbury New Park, and while there he published (in 1882) a work under the title *Moses and Geology*, the object of which was to reconcile scientific facts in geology and astronomy with the Biblical account of creation. This led to much controversy, but passed through several editions. Dr. Kinns was ordained by the Bishop of London (the late Dr. Temple, afterwards Primate) in 1885. Four years later he was presented by the Lord Chancellor to the living of Holy Trinity, Minories, which he held for ten years. In 1891 appeared his *Graven in the Rock*, the purpose of which is to show the harmony between the Biblical narratives and modern discoveries in Egyptian and Babylonian archæology; this work is profusely illustrated by photographs of the slabs and statues in the British Museum. Dr. Kinns also lectured very extensively on the above subjects. His last work, *Six Hundred Years*, gives an interesting sketch of the persons who had been in any way connected with the church in the Minories of which he had been vicar; the most interesting of these relates to the doings of Sir Isaac Newton whilst Master of the Mint. Dr. Kinns was never married, and resided latterly with friends at Haverstock Hill, Hampstead. About two years ago a paralytic seizure incapacitated him for work. He died on the 14th of July 1903, in the seventy-seventh year of his age. W. T. L.

Thomas Mackenzie, eldest son of Roderick Mackenzie, of Muir Houses, West Calder, was born on the 6th of May 1844. He was at school at Aberdeen, and at the age of 13 went to sea. For many years he was in the service of the Royal Mail Steam Packet Company. In 1892 he opened a school of navigation in Fenchurch Street, which he carried on to within a few months of his death. He was the author of *Practical Mechanics for Sailors*, and contributed numerous articles to the *Nautical Magazine* on Seamanship, Stability, Great Circle Sailing, and other questions connected with navigation. Captain Mackenzie was elected a Fellow of the Royal Astronomical Society on the 14th of January 1887. In November 1885 a paper written by him "On

the Application of a Nicol's Prism to Sextant Observations" was published in the *Monthly Notices*, in which he advocated the use of a Nicol's prism to get rid of the glare from the horizon in preference to coloured shades.

Captain Mackenzie died on the 24th of January 1903, leaving a widow.

Arthur Burnett Martin was the son of Captain K. B. Martin, R.N., harbour master at Ramsgate. Born on the 10th of May 1832, he entered the navy in 1845, but was invalided home from the Mediterranean in 1852. From 1852 to 1901 he was a teacher of navigation and nautical astronomy at Norie's Nautical Academy. During this period he prepared large numbers of pupils for the Board of Trade examinations. Most of his pupils belonged to the merchant service, with a small number of yachting men. He appears to have been an excellent teacher, with a faculty for putting things in such a way that they could not be forgotten, and with the ability to make his points clear to his dullest pupils. He wrote a work on navigation and revised *Norie's Epitome*. Mr. Martin was a Fellow of the Society for many years, being elected on the 10th of February 1854. He took great interest in astronomy and often gave lectures locally.

Owing to deafness he rarely attended the meetings of the Society in late years.

Mr. Martin died suddenly on the 5th of March 1903, leaving a widow.

Francis Murray Newton was born at Barton Grange, Taunton, in 1852. He was educated at Eton and University College, Oxford. Soon after leaving Oxford Mr. Newton went with Captain Orde Browne to Egypt as an observer of the Transit of *Venus*, the party to the Mokattam Hills, near Cairo, consisting of Captain and Mrs. Orde Browne and Mr. Newton and his sister, Miss Emily M. Newton. Their camp at Mokattam was formed on the 21st of October 1894 and struck on the 25th of December. The weather seems to have caused the observers a good deal of anxiety, and on the 8th of December, the day of the transit, the clouds did not break till $12^h\ 10^m$, while the expected time of egress was $13^h\ 22^m$. About 10 minutes before contact a thick cloud swept over the Sun and completely obscured it till within 10^s of the contact, when it happily cleared off. Captain Orde Browne with a 6-inch, Mr. Newton with a $4\frac{1}{2}$-inch, lent him by Mr. Warren de la Rue, and Miss Newton with a 3-inch, belonging to her brother, all made satisfactory observations of the time of internal contact at egress and later of external contact.

The volume of *Transit of Venus*, 1874, *British Observations*, contains (Plate X.) drawings by Mr. and Miss Newton relating to the egress of *Venus* as seen by them. There is also an

interesting drawing of *Venus* as seen at 13^h on the 5th of December, about three days before the transit, in which the crescent is 37° more than a semicircle, pointing, Mr. Newton suggested, to an atmosphere on *Venus*. After his return from Egypt Mr. Newton set up his small telescope at his house at Taunton, but his interest in practical astronomy ceased after a few years. In 1879 he started electrical engineering works at Taunton, which are still carried on.

Mr. Newton married in 1879, and leaves a widow, three daughters, and one son.

He became a Fellow of the Society in December 1875.

William Irving Page was born on the 19th of November 1840, at Ulster Place, Regent's Park. His father was an artist of considerable repute, who gained the Academy Gold Medal and Travelling Scholarship, and painted an interesting series of pictures in Greece. Mr. Page was a student at St. George's Hospital, where he was for some time house surgeon. He settled at Wimbledon, where he became very well known and respected.

Mr. Page was a Fellow of the Royal Geographical as well as of the Royal Astronomical Society. He was fond of travelling and had visited nearly all parts of the globe. He had an observatory at his house at Wimbledon, and spent considerable time with his telescope and spectroscope. He became a Fellow of the Society on the 8th of January 1886.

Mr. Page married in 1894, and leaves a widow and one daughter. His death, which took place quite unexpectedly on the 6th of September, was due to pneumonia, which developed from a cold caught while yachting.

Francis Cranmer Penrose was born in 1818, at Bracebridge, near Lincoln, of which parish his father, the Rev. John Penrose, was vicar. After four years at the Bedford Grammar School he obtained a scholarship at Winchester College. After leaving school he was for some time a pupil of Mr. Edward Blore, the architect. He then entered Magdalene College, Cambridge, and was a Senior Optime in the year 1842, the year in which Cayley was Senior Wrangler. While at Cambridge he rowed three times in the boat race against Oxford. After his three years at Cambridge he was appointed "Worts' Travelling Bachelor," a sum of money having been left by Mr. Worts "for the promotion or encouragement of investigations in foreign countries respecting the religion, learning, laws, politics, customs, manners of those countries . . . and for purposes of antiquarian and scientific researches in those countries." In 1851 Mr. Penrose brought out a treatise on *The Principles of Athenian Architecture*. In 1852 he was appointed Surveyor of the Fabric of St. Paul's Cathedral, a post he retained till 1897.

Mr. Penrose became a Fellow of the Royal Astronomical Society in 1867. He had a small telescope at his house at

Wimbledon, with which he frequently made observations. In 1868 he communicated to the Society observations of the transit of *Mercury*, and in 1870 observations of *Algol*, of Sun-spots, and of Occultations. Most of his papers in the *Monthly Notices* are, however, concerned with graphical methods of computation. In 1876 he describes an instrument for solving spherical triangles. The very ingenious method by which he predicted graphically the times of occultations, eclipses, &c., is developed in several papers; for instance, in 1873 he applied it to predict the times of the transit of *Venus* at various stations, and in 1900 to the times of commencement and end of the solar eclipse of that year.* He published an account of his method separately in 1869, and brought out a second edition of it last year. Another paper by Mr. Penrose, which is somewhat of a *tour de force* in the use of graphical methods, was published in the *Monthly Notices* in 1882, "On a Method for Finding the Elements of the Orbit of a Comet by a Graphical Process."

Another subject on which Mr. Penrose wrote was the Orientation of Greek Temples. His first paper is published in the *Philosophical Transactions* for 1893. He proceeded on the theory that in any temple oriented within the solstitial limits of its latitude the axis was so directed that, on the great festival of the year, the first beam of the rising Sun should fall upon the statue centrally placed in the temple, or on the incense altar in front of it; and, further, that the orientation (and consequently day of festival) would be so arranged that the approach of Sunrise would be indicated to the priest by a bright star visible from the *adytum*, and therefore of the same declination as the Sun and right ascension one hour or so earlier than the Sun. If a bright star is identified which satisfies this condition the date of the temple may be determined from the precessional motion. Mr. Penrose found suitable stars for twenty-eight temples, whose orientations ranged from 21° N. to 18° S., and assigned dates to the building of them. He supplemented this paper in 1897, and in 1901, with Sir Norman Lockyer, endeavoured to fix the date of Stonehenge.

Mr. Penrose received the Royal Gold Medal of the Institute of British Architects in 1883. He was elected an Honorary Fellow of Magdalene College, Cambridge, in 1885. In 1886 he was appointed director of the British Archæological Society at Athens, and in 1890 Honorary Antiquary to the Royal Academy. He was elected a Fellow of the Royal Society in 1894, and had been a Fellow of the Royal Astronomical Society since the 8th of February 1867.

Mr. Penrose died at his residence, Colebyfield, Wimbledon, on the 17th of February 1903.

Henry de Worms, first Baron Pirbright, was born in London in 1840. He was the third son of S. B. de Worms,

* See *Monthly Notices*, vol. lx. p. 484.

hereditary Baron of the Austrian Empire, by his wife Henrietta, daughter of Samuel Moses Samuel. Both on his father's and mother's sides he was descended from great mercantile families. Henry de Worms was educated at King's College, London, of which he became a Fellow in 1863. He was first intended for the medical profession, but was ultimately entered as a student of law in the Inner Temple, in 1860, and was called to the Bar in 1863. In 1862 he published a book, *The Earth and its Mechanism; being an Account of the various proofs of the Rotation of the Earth.* In 1874 his family were permitted by the late Queen to use their Austrian titles in England. After other attempts to enter Parliament he was in 1880 returned as one of the Conservative members for Greenwich, and on the reorganisation of that constituency was elected member for the Toxteth division of Liverpool. In 1872 he had published a book on the Austro-Hungarian Empire, and in 1877 another on England's policy in the East; ten years later he translated the *Memoirs of Count Beust.* From 1873 to 1886 he was president of the Anglo-Jewish Association.

Under Lord Salisbury's administration he was appointed in 1885 Parliamentary Secretary to the Board of Trade, and in 1888 Under-Secretary for the Colonies. In 1888 he was raised to the Privy Council, and named a plenipotentiary to the International Conference on Sugar Bounties. He presided at the Conference in London, and with Lord Salisbury signed for Great Britain the treaty for the abolition of the Bounties, but economic and political influences prevented the Convention coming into force. The West Indian trade continued to decline, and De Worms, who had been created Lord Pirbright in 1895, continued the agitation. A further conference on sugar bounties was held in Brussels, resulting in the Convention of 1902, which, however, was materially different from the Convention of London, and Lord Pirbright opposed its ratification by the English Government.

He lived in his later years at Henley Park, Guildford, where he was well known for his numerous charities. He married first the eldest daughter of Baron Todesco, of Vienna, by whom he had three daughters, and secondly Sarah, sister of Sir G. Faudel Phillips. Lord Pirbright leaves no heir.

He was elected a Fellow of the Society on the 13th of December 1861. He died at his London residence in Grosvenor Place on the 9th of January 1903.

Harold Seward was a son of the late Mr. James Seward, of Liverpool and Wandsworth. He was born in 1862 and educated at the Liverpool Institute, where he was Tate Scholar. He obtained a Mathematical Scholarship at Balliol, which he held from 1880 to 1884. He was also a Gilchrist Scholar of the London University. At Oxford he obtained a First Class in Mathematical Moderations in 1882, a Second Class in Natural Science in 1883, and a First Class in Final Honours Mathematics

in 1884. While at Oxford he studied Astronomy with Professor Pritchard and Mr. Plummer.

In 1884 Mr. Seward obtained a post in H.M. Patent Office as Deputy Examiner, which he held till his death. Apart from his work at the Patent Office, in which he was thoroughly interested, Mr. Seward's special interests were orchestral music and astronomy. He joined the Society in December 1884, immediately after his appointment at the Patent Office, and was a regular attendant at the meetings. He joined the British Astronomical Association soon after its foundation, and was for several years on the Council of that body. He contributed to the Society, in January 1896, a "Note on the Indexing of Scientific Papers." In this note, written at a time when the importance of indexing was strongly felt, and the methods to be adopted widely discussed, Mr. Seward offered some suggestions based on his wide experience at the Patent Office. It is interesting to note that the *International Catalogue of Scientific Literature* is being carried out on lines very similar to those indicated by Mr. Seward.

Mr. Seward married Florence, daughter of Mr. Borders, of 10 Balham Park Road. He died on October 14, 1903, after a year's suffering from a painful illness.

Washington Teasdale was born at Leeds, Yorkshire, on the 8th of August 1830. His father died whilst Washington was still a youth, and in consequence his younger brother, his sister and himself were brought up under the chief guardianship of his maternal grandfather, the late Mr. Christopher Heaps, one of the most prominent citizens of Leeds in the middle of the last century. He was educated at Mr. Richard Hiley's Academy, then a well-known school standing near the junction of Queen Square and Woodhouse Lane, and even in boyhood displayed a special interest in scientific pursuits. This appears to have been further fostered by his later training, the profession for which he was designed being that of a civil engineer. When the railway system of India was being constructed, he went out to that country to take part in its development. Here he remained for several years, acquiring such a complete mastery over the native language that it is said he preserved the habit of thinking in Hindustani till the very close of his life. On his return to England he settled in Leeds, and possessing the means, and having ample leisure, he devoted himself to the cultivation of his scientific tastes. These were many and varied, and there was hardly any local scientific society with which he was not connected. In particular he actively interested himself in the Leeds Astronomical Society, the Leeds Naturalist Club, the Scientific Association, the Philosophical and Literary Society, and the Institute of Science, Art, and Literature, throwing himself into whatever subject he took up with most delightful enthusiasm. Photography was an art in which he took especial interest; indeed, he was amongst the earliest workers

in this field, and in conjunction with a few friends, he founded a photographic society before he went to India, when the art was quite in its infancy, and he continued his active connection to the very last with the organisation which had succeeded the original society. He watched the development of the art with the most lively attention, and familiarised himself with every new process as it was introduced. He hardly ever went on a journey, or took a holiday, without his camera, and was continually adding to his rich collection of views. He was one of the first to use the lantern for lecture purposes, and was skilful in the design and preparation of slides for this work. He lectured hundreds of times in connection with various scientific and literary societies; his unaffected delight and interest in the subjects of which he was speaking rendering him in public, as in private, always most attractive.

Astronomy had, however, the chief fascination for him. He was elected a Fellow of this Society in 1886; he was an original member of the British Astronomical Association; and in his native town he had a large share in the resuscitation and the development of the Leeds Astronomical Society, of which he was President from 1893 to 1897. He contributed frequently to its *Journal*, and his services to it cannot be over-estimated.

His love of science amounted to a passion. It had for him an absorbing interest, and for the greater part of his life it was almost his sole occupation, and a hobby which gave a joy to existence. His house in Hyde Park Road, Leeds, was quite a treasury of scientific apparatus, works of art, and interesting curios, and other subjects which denoted the wide range of his studies and sympathies. Outside his more serious pursuits he had many scientific hobbies that afforded himself and his friends amusement. Amongst these may be mentioned, his pendulum writing, an ingenious method of procuring peculiar curved designs of which he claimed to be the originator; then it was the collection of finger prints of eminent men; more recently it was the mixing of inks by which through the medium of a few splashes he obtained the most curious gradations of colour. At one time he made a series of experiments on the problem of the cultivation of trees in large towns; at another he devoted a good deal of study to the monoliths at Stonehenge.

Mr. Teasdale married and had one child, but he survived both his wife and child by many years.

His death took place during the meeting of the British Association at Southport. He had gone thither to attend the meetings, and was visiting a friend, when he was seized with illness, and remained in a state of coma for some time. Hopes were, however, entertained of his recovery, but a second attack followed the next day, and he died on Saturday, the 19th of September 1903, at the age of 72. E. W. M.

Major-General William Henry Wardell, R.A., was the eldest son of Major W. H. Wardell, of the 66th (Berkshire) Regiment and the 93rd Highlanders. He was born in 1838 at Halifax, Nova Scotia. In 1855 he obtained a commission in the Royal Artillery. While a subaltern he served with a detachment of Royal Artillery, which landed Colonel M'Crea for the protection of Europeans at Port au Prince during the revolution in Hayti in January 1859, which ended the reign of the Emperor Faustin. He was for some time an instructor in mathematics at the Royal Military Academy, Woolwich. Later he held the post of assistant-superintendent of the Royal Gunpowder Factory at Waltham Abbey. In 1882, while colonel commanding the artillery in the Windward Islands, he was wrecked with some troops off Barbados. For his coolness and courage on this occasion, which materially assisted in the safe landing of all on board, he received the thanks of the Commander-in-Chief. In 1886 he retired from the service with the honorary rank of Major-General.

General Wardell was the author of *Notes on Gunpowder* and of the article on "Gunpowder" in the *Encyclopædia Britannica*, where he gave an interesting historical account as well as a technical treatment of the subject. He occasionally contributed articles on kindred subjects to scientific reviews. In 1874 he was chosen to observe the transit of *Venus* from the island of Rodriguez, but was prevented from doing so by his military duties. He became a Fellow of the Society on the 14th of January 1876.

General Wardell died on the 24th of July 1903, at his residence, Sparkford Lodge, Winchester, leaving a widow and several children.

William Livingstone Watson was born at Kinross in 1835, and was educated at the Universities of Edinburgh and Glasgow. He entered on a mercantile career in Glasgow in 1855, joining Messrs. James Finlay & Co., a firm of East India merchants. He was a partner in this firm for twenty years, retiring in 1890. From 1876 to 1890 he represented the firm in London. He was for fifteen years chairman of the London Board of the Royal Insurance Company, for some time the Merchants' Marine Insurance Company, and of the Agra Bank, a director of the Indo-China Steam Navigation Company, the Assam-Bengal Railway, the Clan Line of Steamers, and several Indian Sea Companies.

Mr. Watson was a man of very varied interests, and was a Fellow of the Royal Geographical Society and the Society of Antiquaries, as well as of the Royal Astronomical Society. He had at his Scottish residence at Ayton, Abernethy, Perthshire, a 12-inch refractor. This instrument was exhibited at the Great Exhibition in 1851, and was then one of the largest in Great Britain.

Mr. Watson also found time to take an active part in the local

affairs of Perthshire, being a J.P., a member of the County Council, and chairman of two School Boards. He was interested in the working of the Gothenburg system and endeavoured to introduce it into this country.

Mr. Watson was elected a Fellow of this Society on the 8th of January 1892. He married in 1878, and leaves one son. He died on the 19th of May 1903 at his house in Scotland.

Mathieu-Prosper Henry was born at Nancy on the 10th of December 1849. He and his brother Paul went to Paris in 1864, where they became assistants in the meteorological service of the Observatory, Paul in 1864 and Prosper in 1865. They were appointed assistant astronomers in 1868. In their lodgings at Neuilly they succeeded in making a 12-inch mirror and began the construction of an ecliptic chart. When this was brought to Delaunay's knowledge he transferred them from the meteorological to the astronomical side of the Observatory, and on the 1st of July 1871 put them in charge of the "Equatorial du Jardin." They took up the work begun by Chacornac in 1852, interrupted by his death, of constructing charts which should give all the stars down to the thirteenth magnitude in the zone of the ecliptic. Each chart is thirteen inches square, and covers a field of five degrees square, so that seventy-two are required to complete the belt. Chacornac had completed thirty-six of the charts, containing about 60,000 stars. By 1884* the brothers Henry had completed sixteen charts, with 36,000 stars, and nearly finished four more with 15,000 stars. The annual reports of the Director of the Paris Observatory show the progress of the work, and give an idea of the arduous toil and the perseverance of the two brothers. In the course of their work they discovered no less than fourteen minor planets, the first of these, *Liberatrix* (125), being discovered in September 1872. They also made observations of the satellites of *Uranus* and *Neptune*, and sketches of the planets at each opposition. In the winter of 1882 they went to the Pic du Midi to observe the transit of *Venus* from a height of near 10,000 feet at considerable risk to their lives, owing to avalanches. On the day of transit, the 6th of December, the sky was covered with clouds.

As the region of the charts approached the Milky Way the difficulties arising from the large number of stars (15,000 to 18,000 on one chart) made visual observations almost impossible even for observers of their skill and experience. They accordingly determined to try photography, with which Rutherford in America and Common in England had already obtained excellent results, and especially in view of the large number of faint stars shown on Dr. Gill's photograph of the Great Comet of 1882. They first made an object-glass of six and a half inches aperture, and seven feet focal length, achromatised for photographic rays.

* *Comptes Rendus*, t. xcix. p. 305.

In August 1884 Admiral Mouchez presented on their behalf to the Academy of Sciences a photograph of six square degrees of the sky, containing 1500 stars from the sixth to the twelfth magnitude. The exposure given was forty-five minutes. A parallel guiding telescope was used. These results were so satisfactory that MM. Henry, with the cordial support of Admiral Mouchez, commenced the construction of a 12·8-inch photographic objective. It was arranged that a parallel 10-inch guiding telescope should be attached to the photographic telescope. This instrument is the type of those now employed for the international photographic chart of the heavens. It was felt that the difficulties of making large photographic objectives would be overcome. "It is known," M. Mouchez said to the Academy, "that MM. Paul and Prosper Henry are not only excellent observers, but also the most skilful constructors of objectives in France ; we can, therefore, have the greatest confidence in the results of their labours, for the history of science shows that it is always to astronomers who have made their own apparatus that we owe the most remarkable improvements in the instruments of astronomy and the most remarkable discoveries in the study of the sky."

The anticipations of Admiral Mouchez and MM. Henry were speedily realised, and on the 11th of May 1885 it was announced that the instrument was completed and that a field of 3° diameter was very sharply covered. A photograph with an hour's exposure was found to show stars of the fourteenth and some of the fifteenth magnitudes. By January 1886 MM. Henry had obtained a beautiful series of photographs illustrating the power of their instrument, among these a photograph of the *Pleiades*, showing the nebulosities, photographs of the field round σ *Lyræ*, showing the faintest stars recorded by Herschel, and photographs of the clusters in *Hercules* and *Perseus*.

By their persevering labours and great optical skill MM. Henry had made a great step in astronomical studies, of which the importance was soon realised throughout the world. In the course of a few years the project for the complete photographic chart of the sky was commenced, and is now well on its way towards completion.

During the progress of the astrographic chart MM. Henry have contributed several papers to elucidate minor points which arose as the work was being carried out. They have taken the photographs in the Paris zone and were largely responsible for the calculations and reductions. Again, more than half of the instruments engaged in the International Chart and Catalogue of the heavens have come from their workshop.

As illustrating the extent and character of the optical work carried out by MM. Henry it is only necessary to mention some of the larger objectives and mirrors made by them. The list includes the 32-inch photographic refractor, 24-inch visual refractor, and 40-inch mirror of the Meudon Observatory, the

24-inch equatorial coudé of the Observatory of Paris, the 30-inch refractor of the Nice Observatory, and the $31\frac{1}{2}$-inch reflector of the Toulouse Observatory.

In writing of Prosper Henry it has been impossible to separate his work from that of his brother Paul. M. Callandreau, their colleague in the National Observatory, writes * of them : "So united was their friendship and collaboration that at the Observatory we seemed to see but one person ; so forgetful were they of giving prominence to their respective merits that it is impossible to decide what may belong to each of their common work." The astronomers who attended the conferences at Paris, and thus had an opportunity of meeting Prosper Henry, no less than his colleagues at the Paris Observatory, admired equally the modesty of his nature and the variety and extent of his scientific attainments.

He died suddenly on the 25th of July 1903, while taking a holiday at Pralognan, in Savoy.

M. Henry was a Chevalier of the Legion of Honour, and officer of Public Instruction. He was elected an Associate of the Royal Astronomical Society on the 8th of November 1889.

F. W. D.

* *Popular Astronomy*, December 1903.

Proceedings of Observatories.

The following reports of the proceedings of Observatories during the past year have been received from the Directors of the several Observatories, who are alone responsible for the same.

Royal Observatory, Greenwich.
(*Dr. Christie, Astronomer Royal.*)

Transit Circle.—More observations were obtained with the transit circle during the year than in any previous year since its erection, in spite of 1903 having been the wettest of all these years. The number of transits observed was 14,236, and of zenith distances 12,190. Such good progress has been made with the observation of the 10,000 stars within 26° of the pole which will be used as reference stars for the astrographic plates, that it has been decided to terminate these observations at the end of 1905, and form a nine-year catalogue instead of ten-year as originally proposed. The Sun has been observed on the meridian 180 times, its horizontal diameter 139 times, and its vertical diameter 157 times. The Moon has been observed 118 times. The mean error in R.A. of Hansen's Lunar Tables with Newcomb's corrections is $-0^{s}\cdot19$ for 1903. The R−D discordance is exactly the same as last year, the correction to the D observation being

$$+0''\cdot05+0''\cdot26 \sin \text{Z.D.}$$

Great progress has been made in the re-reduction of Groombridge's observations. The revised observations have all been brought to the mean equinox 1810·0. Precessions and secular variations have been computed. The observations have all been compared with modern Greenwich observations, and proper motions derived, and a comparison for check with the Radcliffe Catalogue (1845·0) is in progress. Copy for press of the ledgers and of the catalogue is in progress.

It is proposed to re-examine the comparison of the observations of the Moon made at Greenwich since 1751. Several papers by Mr. Cowell in connection with this work have appeared in the *Monthly Notices* during the year.

The Altazimuth.—This instrument has been used as a reversible transit circle in all four positions. During the year 1461

observations of right ascension and 1084 of north polar distance have been made. Reflexion and direct observations of zenith distance have been obtained in all positions. Eighty-nine observations of the Moon have been made, 37 of these being in the meridian, and 52 extra-meridian. Of the latter 30 were obtained in the first quarter and 22 in the last. Taking the transit circle and altazimuth together, a very large number of observations of the Moon have been secured, distributed with considerable uniformity throughout the lunation. The following table gives the number of days on which the Moon was observed at a given age, and the number of observations with the two instruments :

Moon's Age in Days.	No. of Days Observed.	No. of Observations. T.C.	Altaz.	Moon's Age in Days.	No. of Days Observed.	No. of Observations. T.C.	Altaz.	Moon's Age in Days.	No. of Days Observed.	No. of Observations. T.C.	Altaz.
2–3	2	0	2	11–12	4	4	3	20–21	7	7	0
3–4	2	1	2	12–13	6	6	5	21–22	7	4	4
4–5	6	2	6	13–14	8	7	5	22–23	6	3	4
5–6	8	7	7	14–15	7	7	3	23–24	3	3	3
6–7	5	4	5	15–16	9	9	4	24–25	6	3	4
7–8	8	5	8	16–17	5	5	2	25–26	6	5	3
8–9	6	6	5	17–18	7	7	0	26–27	5	0	5
9–10	7	6	3	18–19	5	5	0				
10–11	8	8	6	19–20	4	4	0				

Reflex Zenith Tube.—During the year 781 complete observations besides 60 observations without reversal were obtained. Attempts have been made to observe the same star for as long a period throughout the year as possible. γ *Draconis* has been observed 65 times, seven other stars at least 20 times, and twenty-seven have been observed 10 times or more.

Equatorials.—Occultations of seventeen stars by the Moon have been observed by one or more observers during the year.

28-*inch Refractor.*—The weather has been very unfavourable for the observation of close and difficult double-stars. In consequence of this, although there is an increase in the number of stars measured, it is almost entirely made up of stars whose distance apart is more than 2″·0. An analysis of the observations gives :

98	of	stars	of	distance $>0''\cdot5$
100	,,	,,	,,	$0''\cdot5-1''\cdot0$
93	,,	,,	,,	$1''\cdot0-2''\cdot0$
153	,,	,,	,,	$>2''\cdot0$

On the average, stars whose distance apart is less than 1″·0 were measured on 2·6 nights, the remainder on 2·1 nights.

The following list contains some of the most interesting stars measured during the year :

Star.	Mags.	Dist.	No. of Nights.	Star.	Mags.	Dist.	No. of Nights.
	m m	"			m m	"	
κ Pegasi	3·9 , 5·0	0·1	13	Σ 1629	6·7 , 7·9	0·3	5
δ Equulei	4·5 , 5·0	0·3	18	Σ 1728	6·0 , 6·0	0·3	4
70 Ophiuchi	4·1 , 6 1	1·6	14	β 612	6·3 , 6·5	0·3	5
Σ 3121	7·5 , 7·8	0·6	6	ζ Boötis	3·5 , 3·9	0·3	6
γ^2 Androm.	5·0 , 6·2	0·4	2	β 80	8·0 , 8·8	0·2	2

Thompson Equatorial.—The dome after twenty years of use was found to require extensive renewal of the papier-mâché covering. This was carried out in the autumn, and afterwards the 30-inch mirror was resilvered on November 27 without removing it from the dome, apparatus for inverting the mirror and holding it when inverted in the silvering solution having been constructed. The telescope was out of use from September 14 to December 2 during the repair of the dome and the resilvering of the mirror.

With the 26-inch refractor 70 photographs of *Neptune* and its satellite were taken on 31 nights, between January 1 and May 4, of which 53 have been measured. From December 2 to December 31 15 photographs were obtained on ten nights ; 21 photographs of double stars, 5 of *Nova Geminorum*, and 12 for adjustments, were also obtained.

With the 30-inch reflector the following photographs were obtained :

Comet *d*, 1902 : 35 photographs on 30 nights.
Comet *a*, 1903 : 18 „ „ 14 „
Comet *b*, 1902 : 6 unsuccessful attempts.
Comet *c*, 1903 : 27 photographs on 27 nights.

In addition, eight long-exposure photographs were obtained of Comet *c*, 1903 (see *Monthly Notices*, 1904 January).

Photographs of 21 minor planets were obtained on from one to six nights each, the average number of nights being three for each planet.

The measurement of the photographs of comets and minor planets is deferred till the photographs of *Eros* of 1900 are measured. For the measurement of the *Eros* photographs a new micrometer, having a glass diaphragm in the focus of the microscope carried on cross-slides by micrometer screws, was obtained from Messrs. Troughton and Simms early in the year. The object-glass of the microscope is so mounted that a magnification of 1 or 2 in the body of the microscope can be used at pleasure to adapt it to photographs with the Thompson and Astrographic telescopes respectively. At the beginning of the year the screws were examined, the division errors of the diaphragm determined, and the distortion of the microscope object-glass investigated. About the same time the errors of the diaphragms belonging to the duplex micrometer were determined. The errors of the

réseau employed in the *Eros* photographs were also investigated. The actual measurement of the photographs was not begun till October, and since then has been pushed on energetically.

Astrographic Equatorial.—During the year ninety-one photographs were taken on forty-six nights. These include eleven for the catalogue, twenty for the chart, twenty of *Nova Persei*, a few miscellaneous photographs and nine for adjustment of the instrument. The number of plates measured (direct and reversed) in the year was 104. The measurement of the Greenwich plates is completed from Dec. 79° to Dec. 82°. Altogether 1002 plates out of 1149 containing 1879 square degrees out of 2088 (90 per cent. of the total amount) have been measured. The numbers of stars measured in the three zones are :

Zone.	No. of Stars.	Area in Sq. Degrees.	No. per Sq. Degree.
79°	7380	65·6	112·5
80°	5980	59·4	100·7
81°	4750	53·2	89·3

The Introduction to Vol. 1 of the *Astrographic Catalogue* is in type. This volume contains the measures of rectangular coordinates and diameters from 64° to 72° N. Dec., together with plate constants and other data. These measures will be continued to the pole in Vol. 2. It is intended to give in Vol. 3 a catalogue of R.A. and N.P.D. (1900·0) of all the reference stars and all the stars found in the catalogues of the *Astronomische Gesellschaft* (1875), and in Carrington's *Circumpolar Catalogue* (1855).

Copy for press has been prepared for Zones 72°, 73°, and 74°.

During the year the stars visible on 108 chart plates have been counted, completing the area from Dec. 64° to Dec. 71°.

The reproduction of the chart plates by purely photographic processes has just been begun. The number of copies made in the first instance will be fifty of each chart plate. These will be on bromide card and on double the scale of the original negatives.

Photoheliograph.—Photographs of the Sun have been taken on 176 days with the Thompson (9-inch) photoheliograph, and on 59 days with the Dallmeyer (4-inch), during the repair of the Thompson dome. Of the photographs 545 have been selected for preservation. Photographs have been received from India up to 1903 October 7 ; for the year ending 1903 October 7 photographs are available for 334 days out of 365. Photographs from Mauritius have not been received since the date of the last annual report, the last negative received at Greenwich being for 1902 June 20, and it is hoped that some of the numerous gaps will be filled when these photographs are received. The Greenwich photographs are measured to 1903 August 8, the Indian ones to October 7. The increase of solar activity during the year has been very marked, the group of spots from October 4 to October 18 being an especially large one.

The reductions of the observations by the Greenwich

observers for the determination of the Paris-Greenwich longitude were completed in May.

The printing of the Greenwich-Waterville-Canso-Montreal longitude is in progress.

Professor Albrecht and Dr. Wanach made a determination of the longitude Potsdam-Greenwich from May to July.

In July and October Major Burrard and Major Lenox-Conyngham swung the half-seconds pendulums, which they are to use for the Indian Survey, in the Record room of the Observatory.

The volume of Greenwich Observations for 1901 is printed, and will be distributed shortly.

Mr. W. C. Nash retired on December 31, after a long and honourable connection with the Observatory of nearly forty-eight years. Mr. Bryant has succeeded him in the Superintendence of the Magnetic and Meteorological Department.

Royal Observatory, Cape of Good Hope.
(Sir David Gill, H.M. Astronomer.)

The weather generally throughout the year has been exceptionally unfavourable for astronomical observation, and much of the time of H.M. Astronomer has been occupied with the installation, adjustment of, and experimentation with new apparatus.

The pits which give access to the underground azimuth marks of the new transit circle, described in former reports, have at last been lined with iron. The houses covering the collimators and marks have been erected, the piers built, the collimators erected, and the wires laid and fittings installed for electric illumination of the marks and pits.

The object-glasses of long focus for adjusting the upper marks vertically over the underground marks have not yet been received from Mr. Simms, but he promises their early delivery.

A very thorough investigation of the division errors of the new transit circle has been in progress during the year, but is not yet complete. It is intended to investigate the error of every division line on the fixed circle (5′ to 5′), and on the movable circle only the lines marking whole degrees. The results, so far as they go, are most satisfactory in every way. The probable error of a single pointing, derived from the residuals from interwoven series made by the same observer, is $\pm 0''{\cdot}18$; and the same probable error, $\pm 0''{\cdot}18$, is derived whether we group the observations so as to include or avoid the effects of flexure of the circle, or obtain it from comparison of the division errors as independently determined by different observers. The fact that the circles are solid cast-iron discs without arms accounts for their rigidity, and the general stability of the instrument and the clearness of the division under the new illumination account for the freedom of the investigation from unforeseen systematic error or personality in reading the divisions. Mr. Hough has communicated a paper to the Society on the methods employed.

An eye-end has recently been received from Repsolds which permits the observation of transits with a moving wire—that is to say, the wire is caused to travel at a rate approximately equal to that of the star either solely by the hands of the observer himself, or with the aid of clockwork which can be set to run at nearly the required speed. In both cases the eyepiece travels with the wire, so that, when properly managed, the star appears at rest in the centre of the field. The observer has thus merely to maintain the bisection of a star on a wire which is apparently fixed in the centre of the field, and the chronograph records are automatically made by electric contacts with alternate conducting and non-conducting pieces on the drum of the screw which causes the wire to travel.

Much time has been spent on plans for perfecting this system of observation, which seems to be the only one by which we can get rid of personality in R.A. depending on magnitude and on declination.

The spectroscope of the Victoria telescope, which had been in the hands of the Cambridge Scientific Instrument Company since May 1901, arrived at the Cape on May 27 last. It is now fitted with four new very transparent prisms, made of lighter flint glass than that of the three original prisms, which were rather highly coloured and absorbed too much of the violet rays. In addition the spectroscope is now enclosed in a double aluminium cover stuffed with feathers, and with exquisite automatic means for maintaining the included air at uniform temperature by means of automatically regulated electric currents passing through coils of manganin wire. An electric fan inside the aluminium cover circulates the air, to preserve uniform temperature throughout. The temperature inside the prism box is registered continuously on a drum by a Callendar recorder, giving 1° F. = one inch, and can be maintained for days together within $\pm$0°·1 F.

The new sidereal clock arrived at the same time with the spectroscope, and it has been mounted in the now disused magnetic house.

This clock is certainly the most elaborate, and probably by far the most perfect, yet constructed. It consists essentially of a pendulum swinging in a nearly air-tight glass enclosure, the air in which is maintained automatically at uniform temperature and low uniform pressure. The impulse given to the pendulum depends on gravity only, and is entirely independent of the effects of any sticking or repulsion at points of electric contact. The pendulum of the slave clock is rather shorter than the main pendulum ; it is "held up" by a spring catch for about one-tenth of a second at each alternate beat, and this catch is discharged by a trigger, the electric magnet of which is short-circuited at each alternate second by the fall of the light gravity arm of the main pendulum on a fixed platinum anvil. The slave clock pendulum performs all the contacts necessary, *i.e.* for raising and

lowering the gravity arm of the main pendulum at the proper instants, and for making the contacts for the chronograph; it also indicates the minutes and seconds ; it periodically actuates the feeler connected with the temperature control, and makes the contacts connected with the automatic control of the pressure. A detailed description of the instrument is in course of preparation.

The progress in printing the catalogue of 8560 stars has been very slow ; only 120 pages (0^h to 13^h) have been received from the printer during the year.

Part i. vol. xi. of the *Cape Annals*, containing a discussion of the Heliometer Triangulation of Southern Circumpolar Stars within 2° of the South Pole, has been passed through the press and is ready for distribution.

Part ii. of the same volume, containing the results of a discussion of photographic plates covering the same region, is ready for press.

The work of the transit circle has been confined to the completion of a catalogue of 2798 selected zodiacal stars, besides all stars brighter than 8·1 magnitude which are not contained in Gould's General Catalogue (excepting those in the zone Decl. −40° to −52°, most of which are included in the Cape Catalogue for 1900), stars required for geodetic purposes and stars of which occultations have been observed at the Cape. A few observations, which will be obtained during the month of January, are only now required to complete the work. A final redetermination of the magnitude equation of the observers will complete the work of the old transit circle for the present. The completion of a catalogue necessarily involves considerable lacunæ in the observing list, so that the total number of observations is somewhat less than usual, viz. :

Number of transits ...	6262	Azimuth	304
Determinations of Z.D.	5711	Run	269
Collimation	98	Nadir	267
Level	268	Flexure	23

The reductions of the meridian observations to apparent place are complete to the end of 1903. The reductions to mean place are complete in R.A. to September 18, and in Declination to August 20.

Only sixteen separate phenomena of occultations have been observed, all of which were predicted by the *Nautical Almanac* Office.

Disappearances at the dark limb	12
Reappearances „ „	4

Five of these phenomena were observed by two observers.
One „ „ was „ three „

The following observations of comets have been made by Mr. Cox :

Comet *a* 1903 on 8 nights } *Ast. Nach.* 3906.
b 1903 „ 11 „ }
c 1903 „ 6 „ forwarded to *Ast. Nach.* Nov. 18.

The star *C.P.D.* −62°, 6358, has been proved to be a long-period variable, 8·0 mag. to invisible. The positions of forty-five faint stars of which occultations have been observed were determined by differences of R.A. and Decl. from known stars with the 7-inch equatorial.

In February and March Mr. Innes made with the 18-inch object-glass of the Victoria telescope 161 sets of measures of 108 double stars, two of which were of new pairs, the series including ten sets of measures of *α Centauri*.

During Mr. Lunt's absence Mr. Goatcher has measured and discussed all the lines visible in the spectra of *Canopus* and *Sirius* taken with the three-prism spectrograph. Within the limits of λ4202 and λ4584 he finds the spectrum of *Canopus* to contain the lines of H, Fe, Ti, Cr, Sc, Ca, Mg, Ba, Sr, Y, C ?, V ?, Zr ?, and these elements account for all the lines visible. The spectrum of *Sirius* within the same limits shows the presence of H, Fe, Ti, Cr, Ca, Ba, Sr, Mg. He has also measured and reduced photographs of the spectra of α_1 and α_2 *Centauri*, *β Orionis*, *α Pavonis*, and *α Scorpii*.

Previous to July the Victoria telescope was employed by Mr. Goatcher in photographing star clusters and nebulæ.

Between July 22 and November 7 the instrument was dismounted for the purpose of adapting the remodelled spectroscope with its automatic temperature control and the Callendar recorder, which registers continuously the temperature of the interior of the prism box. The mounting of the numerous electric leads, the re-balancing of the telescope, the fitting and adjustment of all subsidiary apparatus and switches occupied some months. One hundred and four photographs were taken for the focussing and adjustments of the spectrograph—mainly by Newall's method. In this method one part of the slit is used, and the image of the spectrum is formed by rays passing through one half of the collimator objective and through the thinner half of the prisms ; immediately afterwards another adjacent part of the slit is used, and another spectrum is photographed on the same plate by rays which have passed through the other half of the collimator object-glass and through the half of the prisms adjacent to their bases. With the present object-glass of the camera telescope it is impossible to obtain coincidence of the lines in two such photographs throughout the entire length of the spectrum. With proper adjustment the lines coincide for a certain distance and then deviate like those of a very fine vernier. In the remodelled spectroscope a screen is provided, which moves in a slide, so that

it can be pushed in front of either half of the object-glass or clear of it. This slide is worked by a rod coming outside the aluminium case, and a spring, dropping into proper notches, enables the observer to place the screen exactly in any one of the three requisite positions.

Experience with the original spectroscope showed the necessity for this, as a perceptible systematic difference in the apparent radial velocity, amounting to several kilometres per second, was obtained from measures of lines in different parts of the spectrum. This anomaly has its origin in the different exposure required for rays passing through a greater or less thickness of glass. If the spectrum is over-exposed the mean image of a line photographed with the full aperture would depend in greater proportion on the rays which pass through the half of the prism next to the base than would be the case in an under-exposed spectrum ; and it is practically impossible to maintain an exact relative density between the image of the comparison spectrum and that of the star. The remedy appears to be to use for determinations of radial velocity only those lines which are in perfect coincidence when separately photographed through the thick and thin halves of the prisms. For this purpose the rule has been laid down to take through both halves of the prisms a plate of the iron spectrum immediately before or after any photograph intended for determination of radial velocity, and to use for the velocity determinations only the part or parts of the spectrum in which the lines in the two adjacent spectra are in perfect coincidence. The whole of the experiments and adjustments were completed on November 7, but, in consequence of the exceptionally unfavourable weather, only twenty-two plates of spectra could be obtained on thirteen nights before the end of the year.

The most remarkable result obtained is the rapid radial velocity of *α Phœnicis*, which in December was receding at 105 kilometres per second from the Earth and 82 kilometres from the Sun.

The new objective prism of 24 inches aperture and $11\frac{1}{4}^{\circ}$ of refracting angle in a new mounting, which permits its use alone or conjointly with the Grubb prism, was received from Messrs. Zeiss at the end of November, but has not yet been adapted to the telescope.

The following oppositions of major planets have been observed with the heliometer during the year :

	No. of Obs.	Nights.
Opposition of Mars	20	4
,, ,, Uranus	24	3
,, ,, Saturn	32	4
,, ,, Jupiter	44	6
,, ,, Neptune	30	6

The following observations have been made in connection with the triangulations connecting the comparison stars :

	Observations.
For Neptune, 1901–4	87
„ Mars, 1901	55
„ Uranus, 1901–2	154
„ Saturn and Jupiter, 1901	132
„ Saturn, 1903; Jupiter, 1902	57
„ Jupiter, 1903	25

Fifty observations have also been made connecting the position-angles and distances of the stars employed as standards for the photographic plates of *Jupiter's* satellites in the oppositions of 1902 and 1903, with pairs of stars contained in the triangulation of the *Victoria* comparison stars.

Comet *a* 1903 was also observed with the heliometer on seven nights.

The reduction of the fine series of heliometer observations of *Jupiter's* satellites made by Mr. Cookson in 1901 and 1902 is completed, and Mr. Cookson is now engaged in England in deriving the elements of the orbits, the mass of *Jupiter*, and the constants of the inequalities which involve the masses of the satellites.

With the astrographic telescope the following work has been accomplished :

	No. of Plates.	No. of Exposures.	Duration of each Exposure.
			m m m
Triple-exposure chart plates (Ilford S.R.) passed	22	66	30, 30, 30
„ „ „ „ „ „ rejected	18	54	30, 30, 30
„ „ „ „ (Ilford Monarch) passed	80	240	20, 20, 20
„ „ „ „ „ „ rejected	11	33	20, 20, 20
			m m s
Revision Catalogue plates (Ilford S.R.) passed	104	312	6, 3, 20
„ „ „ „ „ rejected	53	159	6, 3, 20
„ „ „ (Ilford Monarch) passed	110	330	3, 1½, 10
„ „ „ „ „ rejected	37	111	3, 1½, 10
Jupiter's satellites	33	297	5ˢ & trail
Adjustment plates	9	...	various
Comet *a* 1903	7	7	„

The following table gives the work done to the end of 1903 :

Mid. Dec. of Zone.	Triple Image Charts. Taken.	To be Taken.	Single Image Charts. Taken.	To be Taken.	Second Series. Catalogue Plates. Taken.	To be Taken.
°						
−41	130	14	...	...	143	1
42	...	...	126	18	142	2
43	124	20	...	...	140	4
44	...	...	123	21	114	30
45	106	38	...	...	111	33
46	...	...	124	20	109	35
47	108	36	...	...	104	40
48	...	...	123	21	83	61
49	84	36	...	...	59	61
50	...	...	104	16	52	68
51	68	52	...	...	50	70
−52	...	...	65	55	...	...
	620	196	665	151	1107	405

The first series of Catalogue Plates is completed.

In the measuring-room a good deal of time has been spent in training new observers and in revising old work.

During the year 1903 156 Catalogue Plates, containing 80,808 stars, have been measured in two positions of each plate—including 1866 Standard Stars, each of the latter being measured in two positions of the plate by both the measurers employed on each plate. Four plates measured in former years have since been rejected. The total number of measured plates is now 586, containing 328,000 stars. The actual state of the work is as follows :

Catalogue Plates.

Mid. Dec. of Zone.	No. of Plates Measured. Before 1903.	During year 1903.	Out-standing.	No. of Plates Copied for Press. Before 1903.	During 1903.	Out-standing.
°						
−41	139	4	1	96	47	1
42	110	31	3	27	17	100
43	99	41	4	73	...	71
44	50	48	46	28	...	116
45	26	32	86	14	5	125
46	2	...	142	...	...	144
47	4	...	140	...	...	144
48	...	...	144	...	...	144
49	...	...	120	...	...	120
50	...	...	120	...	...	120
−51	...	...	120	...	...	120
	430	156	926	238	69	1205

The total number of separate star-discs measured on the Catalogue Plates of the Cape Zone will probably amount to about one million, corresponding with about 400,000 different stars.

The tabular coordinates of the reference stars (from the data of the *Cape Zone Catalogue* for 1900) have been computed for all the plates of all the zones, and the plate constants have been computed for all plates of the zone $-41°$, except of course for the single plate that is still wanting. For the same zone the coordinates of all the C.P.D. stars have been approximately computed, and these have been compared with the recent measures ; the corresponding C.P.D. numbers have been entered on the sheets for press.

The work of the Anglo-German Boundary Survey between German South-West Africa and British Bechuanaland has been completed.

The reports of the work of the Anglo-German Boundary Survey and of the Geodetic Survey in Rhodesia south of the Zambesi are practically complete, and will be ready for press within a few weeks.

The geodetic operations in the Transvaal and Orange River Colony were actively commenced in January 1903, under the superintendence of Colonel Morris, R.E., C.B.

The following represents the scope of the Survey:

I. *a.* Newcastle (Natal) to the Limpopo (along the 30th meridian), 415 miles.

b. Limpopo to Ottoshoop, 230 miles.

c. Belfast to Ottoshoop, 240 miles.

d. Newcastle to Christiana, 220 miles.

e. Ottoshoop to Kimberley, 245 miles.

f. Pretoria to Cala (through Kroonstad), 405 miles.

g. Hopetown to Natal (through Wepener), 320 miles.

h. Newcastle along 28th parallel to the sea, 140 miles, representing chains of triangulation of an approximate total length of 2215 miles.

Of this work there has been completed:

Reconnaissance	...	...	...	53 per cent.
Beaconing	...	...	...	13 „
Observation of angles	...	...	...	5 „

Only one 10-inch Repsold Theodolite was available during the year. Two similar instruments were shipped for the service by Messrs. Repsold on November 25.

Of the ten triangles measured the greatest triangular error is $+1''{\cdot}52$, and the probable error of a single angle derived from all the triangular errors is $\pm 0''{\cdot}327$.

II. *Base Lines*—

k. Belfast, 11·8 miles in length.
l. Ottoshoop, 10·8 „ „
m. Wepener, 13·5 „ „
n. Kroonstad, 12·5 „ „
r. Limpopo (not yet selected).

Of these *k* and *l* have each been independently measured three times, and *m* twice (the third measurement was being made at the date of report, December 29); *n* was selected and laid out by Colonel Morris in November, and will be measured on the completion of *m*. The site of the remaining base south of the intersection of the Limpopo by the 30th meridian has not yet been definitely selected, but it is expected that its measurement will be commenced in May 1904, when that region will probably be free from malaria and horse sickness.

These base lines have been measured with Jäderin wires of nickel steel. The experience now gained with that apparatus shows conclusively that when properly used all desirable accuracy can be secured.

A length of 480 feet was first laid down near the centre of each base and carefully measured with the standard 10-foot bars, of which the constants have been determined by comparison at the International Bureau of Weights and Measures (*Geodetic Survey of South Africa*, vol. i.). The lengths of the wires used in the reductions depend in all cases on numerous comparisons with the 480-foot ground standards.

The results of the measures are as follows :

	Belfast Base. Metres.	Ottoshoop Base. Metres.	Wepener Base. Metres.
Measure 1	18,994·027	17,438·188	21,655·265
2	·077	·182	·294
3	066	·163	...
	m.	m.	m.
Accidental prob. error of mean...	± 0 0101 or ± 0·0093(9)	± 0·0050 or ± 0·0046(8)	± 0·0145 or ± 0·0086(6)

Of these probable errors the first depends on the inter-agreement of the separate measures of the whole length of the base, the second on the inter-agreement of the measures of the separate sections of the base. The number of sections in each base is given in brackets. These probable errors do not include the probable error of absolute length of the 480-foot ground standards, which were measured with the steel bars at each comparison of the Jäderin wires, and this error does not amount to 1 : 1,000,000, including the error of the absolute length of the

bars, which is the largest part of the probable error. The mean of three measures with the Jäderin wires fully attains to a corresponding accuracy.

For the measurement of the arc of meridian from the Zambesi to Lake Tanganyika I have selected Dr. Tryggve Rubin, who was a member of the Swedish-Russian expedition for measurement of the Spitzbergen arc of meridian in the summer of 1901, and leader of the expedition which completed that work in the summer of 1902. After residence and work for three weeks at the Cape Observatory he sailed for Chinde on April 29, accompanied by Dr. F. O. Stoehr, M.B. (surgeon of the expedition), and Messrs. Edward Stroud and Paul Chapman as assistants. The party arrived at Chinde on May 12, where they were detained a week in landing and reshipping their instruments for Feira. The party proceeded to Fort Jameson, where the equipment of the expedition with native carriers was completed, and it finally reached its field of operations at Feira, on the Zambesi, on July 13. The season had been very dry; grass fires had begun, and any work beyond reconnaissance, beaconing, and astronomical observation was rendered impossible by the smoke which completely obscured the horizon. On the way from Fort Jameson to Feira reconnaissances were made for a base line, and an excellent site was selected of nearly 10 miles in length on a plain alongside the river Loangwa, near its intersection with the parallel of $-15°$. The measurement of the base itself is deferred pending the arrival of a $2\frac{1}{2}$-metre standard, obtained on loan from the Russian Government at the request of the Royal Society.

A considerable amount of line-clearing and beaconing had been performed, and a number of astronomical determinations of latitude and azimuth had been made at the date of last report (September 3), but the dense smoke of the grass fires had greatly hindered progress. Dr. Rubin was, therefore, instructed to demarcate the Portuguese boundary running due south from the Zambesi near Zumbo, and to fix by astronomical observation the point where the 15th parallel of latitude crosses the river Loangwa.

These matters will facilitate the operations of our Anglo-Portuguese Commission (which is about to commence the work of definitive demarcation of the boundary between British and Portuguese territory), and will probably be completed before the end of the first rains (in October), when the sky will be free from the smoke of grass fires and geodetic operations may be resumed.

Mr. G. Tyrrell McCaw, who was appointed chief assistant to Dr. Rubin, left for Feira *via* Salisbury on October 5, having spent a month at the Observatory for training in astronomical work. He took with him the spare theodolite and nickel steel wires for the Jäderin apparatus.

The records of the seismograph have been regularly for-

warded to Professor Milne, Secretary to the Seismological Committee of the British Association.

The meteorological observations made during 1903 have been communicated to the Cape Meteorological Commission.

Mr. Franklin-Adams arrived at the Cape on July 28. His assistant, Mr. Kennedy, reached the Cape a month before him to erect the fine photographic equatorial with a triple lens, by Cooke, of 10 inches aperture and 45 inches focal length, with which he is making a star chart of the southern hemisphere on plates covering $15° \times 15°$. The work is now half completed, with satisfactory results.

Royal Observatory, Edinburgh.
(Dr. Copeland, Astronomer Royal for Scotland.)

The programme for meridian observations included the zodiacal stars and heliometer comparison stars in Sir David Gill's lists, and the *Berliner Jahrbuch* clock star-list. The total number of observations, all of which were made by Mr. Clark, was 1478, of which 995 were of stars in Sir D. Gill's lists, 396 of clock stars, 72 of azimuth stars, and 15 of planets. With the exception of a few clock stars, each of these observations included measures of both right ascension and declination. The instrumental errors were determined both at the beginning and end of each night's work. The instrument appears to have maintained its stability throughout the year. Owing to the fracture of one of the bevelled wheels used for raising the roof shutters of the meridian house, observations were interrupted for ten days in December.

The spectroscopic observations of the rotation of the Sun, commenced by Dr. Halm in 1901, were continued by him throughout the year, and measurements of the displacements of the Dunér iron lines on opposite limbs were secured on all favourable occasions. Rotational values for nearly 200 heliographic latitudes were measured, extending over the full quadrant from the equator to the pole. A comparison of the resulting curve with that obtained in the preceding years points conclusively to the fact that the vigorous initiation of the new cycle, manifested during the past year by considerable activity on the Sun's surface, was attended by a change in the Sun's rotation of a most pronounced character. Although a definite opinion as to this change cannot yet be expressed, its reality seems clearly established by the observations. A paper on the subject will shortly be laid before the Royal Society of Edinburgh. The instrument appears to work admirably; this is perhaps best shown by the fact that the probable error of a measurement is only one-half of that of an observation made by Professor Dunér.

The catalogue of the stars observed by the late Professor Henderson and Mr. Wallace during the years 1834–45 is now

completed. A thorough comparison has been made by Dr. Halm and Mr. Blackett with other catalogues, especially Lalande, Piazzi, and the catalogues of the *Astronomische Gesellschaft*. The differences Edinburgh-*Astronomische Gesellschaft* catalogues in both co-ordinates have been formed in the order of right ascension as well as in that of declination. One object of this investigation was to ascertain whether systematic differences exist between the first period, extending from 1834 to 1840, and the second, extending from 1841 to 1845. Such differences have, indeed, been found, especially in the declinations, where, however, they can be well accounted for by the assumption that there was a constant difference of about 2° F. in the indications of the thermometer in the two periods. No note has been found that would give a clue to the cause of such a difference in the thermometer readings.

Occasional observations of minor planets and comets and a determination of the screw value of the micrometer were made by Dr. Halm with the 15-inch refractor. With the same instrument micrometer observations of Comet 1903 *c* were made by Mr. Clark on eight nights, two or three comparison stars being observed each night.

The time service for the cities of Edinburgh and Dundee has been conducted as in former years, being controlled by the Molyneux mean time clock of this Observatory. On five days during the year the one o'clock gun was not fired. On one of these days both of the friction fuses used missed fire, a most unusual occurrence, as the misfire of a single fuse is expected to happen on an average only once in a thousand times ; on the other four days the apparatus was under repair. The time ball was not raised on February 7 on account of the violence of the gale of that day. It may be mentioned that in this gale a velocity of not less than eighty miles an hour was recorded by the anemometer.

The Milne seismograph has been again in operation during the year, and the photographic record shows traces of fifty-seven unfelt earthquakes, all of semi-amplitude not less than 0·25 mm. Of these five only were of large amplitude, the most remarkable of them being that of January 14, of which the semi-amplitude amounted to 11 mm. Copies of the records of this instrument are forwarded regularly to Professor Milne, Secretary to the Seismological Committee of the British Association for the Advancement of Science.

The lunar eclipse of April 11 was observed by the staff. A few photographs were obtained by Mr. Heath, and the first and last contacts, two immersions and four emersions of faint stars, were observed by Mr. Clark.

Watch was kept, by request, for the *Lyrid* meteors on the night of April 19, and for *Leonids* on November 14. No meteors were seen on either of these occasions, both the nights being unfavourable for such observations.

The usual meteorological observations have been made by the

staff of the Observatory. The Robinson anemometer and the King's barograph have been kept in operation throughout the year and the records tabulated with regularity. The weekly readings of the deep rock thermometers on the Calton Hill have been continued.

Cambridge Observatory (*Sir R. S. Ball*).

After nearly forty years' work as chief assistant, Mr. Graham retired on a pension on June 24. At the same time Miss Walker resigned the position of computer, which she had held for twenty-one years.

Mr. A. R. Hinks, M.A., Trinity College, has been promoted to be chief assistant, and took up residence at the Observatory in September.

Meridian Circle.—In the first four months of 1903 the meridian circle was used by Miss Walker on thirty-six nights in observation of Gill's zodiacal stars.

With the resignations above referred to a complete break has been made in the work of the meridian circle. Of the zodiacal stars about half are fully observed, and the reductions are complete.

In July Mr. W. E. Hartley, M.A., Trinity College, Cambridge, was appointed second assistant, and took up the meridian work. After a thorough examination of the state of the instrument it was decided that a number of repairs and improvements should be made before regular observation was resumed; and these alterations have occupied the latter months of the year. The principal additions to the instrument are a printing arrangement for the declination micrometer, a large setting wheel and new pointer, and a mercury dot apparatus, as described by Sir David Gill, for the determination of pivot errors.

A copy of the results of the observation of Sir David Gill's first list of heliometer comparison stars has been sent to him. The observation of the second list is complete, and will be sent shortly.

Sheepshanks Photographic Equatorial.—With the aid of a grant from the Government Grant Fund of the Royal Society the reduction of photographs of *Eros* for the determination of the Solar Parallax has progressed steadily during the year. Mr. Hinks has been assisted by Miss Julia Bell, Girton College, during the whole year, and by Miss Anne Malden, Newnham College, since October. The present state of the work is as follows :—

Eighty-nine exposures made at Cambridge are completely measured. To combine with these there are measures of 144 exposures kindly communicated by the Directors of the Paris, Algiers, Lick, Minneapolis, Northfield, Tacubaya, and San Fernando Observatories.

A system of standard places of comparison stars has been deduced from measures made at Paris and Cambridge ; at least ten of these stars are measured upon nearly all the plates. The reduction of all the measures of the planet to this standard system is in progress and will shortly be finished. All the interpolations from the ephemeris and calculations of parallax factors, &c., are completed, ready for the formation of the final equations of condition.

A copy of the adopted places of comparison stars has been sent to the Oxford University Observatory at the request of the Director.

Mr. H. N. Russell, formerly Fellow of Princeton, and recently appointed a Research Assistant to the Carnegie Institution, has joined the staff as an honorary assistant, and has been actively at work with the photographic equatorial. The working list of stars selected for parallax determination has been greatly enlarged, to serve as a programme of joint work by Mr. Hinks and Mr. Russell. In the course of the year 183 exposures for measurement have been made, in addition to a large number of plates made in the trial of partial colour screens, used in contact with the plate, for reducing to measurable dimensions the photographic images of bright stars. The division errors of the standard réseau, Gautier, No. 86, have been determined.

Meteorological Observations.—At the end of the year the climatological observations were discontinued at the Observatory, the Cambridge " station of the second order " having been transferred to the University Botanic Garden.

It is proposed to devote the energy thus set free from routine work to the gradual establishment at the Observatory of experimental researches in atmospheric physics. As a beginning the following instruments are now being set up at the Observatory :

1. A Bendorf electrograph, with radium radiator, lent by Dr. W. N. Shaw, F.R.S.

2. A Dines self-recording barometer, lent by the Meteorological Council.

3. An equatorially mounted Callendar sunshine receiver, lent by Mr. W. E. Wilson, F.R.S.

Mr. C. T. R. Wilson, F.R.S., is kindly supervising the erection and standardisation of the instruments.

The records will be deposited at the Meteorological Office.

The Newall Telescope, Cambridge Observatory.
(*Mr. H. F. Newall.*)

The Newall telescope was used for observations on eighty-three nights in the course of the year 1903.

The work throughout the year has been a continuation of the spectroscopic studies carried on in recent years, principally in the

determination of velocity in the line of sight. Special attention has been given to the spectra of *Sirius*, *Procyon*, *α Boötis*, and of certain stars in Taurus. Observations of chosen "velocity-reference-stars" have been continued in co-operation with other observatories; and a note giving results relating to some of these stars as observed in 1902 was published in the *Monthly Notices*, March 1903, lxiii. 296.

One hundred and sixty-eight (168) photographs of stellar spectra have been obtained, including a few in which pairs of spectra of different stars are set side by side on the same plate for purposes of rapid comparison. Many other photographs have been rejected for various reasons. The adjustments of the instrument have been regularly tested by means of special photographs.

Dunsink Observatory.
(*Prof. C. J. Joly, Royal Astronomer of Ireland.*)

Systematic work with the meridian circle was suspended during the year 1903 in order to devote all possible attention to the reduction of the observations of Sir David Gill's Zodiacal Stars made in 1900, 1901, and 1902, and completed in 1902. All these observations are now reduced to apparent place, and those taken in 1900 are reduced to mean place. The precessions and secular variations have also been computed for the observations of 1900.

Advantage was taken of the interruption of continued observation in order to overhaul the instrument. The mirrors for the illumination of the field were re-silvered, and the object-glass was thoroughly cleaned and some traces of fungus removed. On readjustment the definition was found to be considerably improved.

About 200 observations were made with the meridian instrument during the year for the determination of time, the time-service to Dublin being continued as usual. An investigation was also made into the barometric and thermometric variations of the rate of the Dent sidereal clock over a long period, and tables were drawn up to facilitate the application of the necessary corrections. These tables have proved very satisfactory.

A large number of barograph records of the great storm of February last, which was especially severe in the neighbourhood of Dublin, were sent by request to the Observatory from various parts of Ireland. These were carefully compared and discussed, and a short account of the results was published in *Symons's Meteorological Magazine*.

A number of photographs were taken with the Roberts equatorial, and the South equatorial was chiefly used for showing objects of interest to visitors on the monthly open nights.

University of Durham Observatory. (*Prof. R. A. Sampson.*)

Work with the almucantar during the year has been confined to the preparation of an account of the observations taken up to 1902 December. This was published in *Monthly Notices*, April. The severe storm of February 26 blew the dome off the almucantar house; the telescope did not suffer, but advantage was taken of the interruption to overhaul it, to re-silver the mirror and fix it more securely in its cell.

During the year a memoir describing Adams's MSS. on the perturbations of *Uranus* has been prepared for the press by Professor Sampson; it is being published in the R.A.S. *Memoirs*, vol. liv.

Apart from this all available time has been devoted to pushing on the *Jupiter's Satellites* computations; these are now well forward and a solution of the normal equations is being made. The work has been assisted by a grant from the Government Grant Committee. A considerable body of completed MS. has been despatched during the year to Harvard College Observatory for publication.

Glasgow Observatory. (*Prof. L. Becker.*)

Owing to the continued unfavourable weather in the past year little progress was made with the observations of the stars in the immediate vicinity of the pole. These stars are measured during a night at several points of their daily orbits, with the transit circle, with the object of determining the position of the pole and the coordinates of the fundamental pole-stars. During the first and last quarters of the year, which, on account of the length of the nights, are most favourable for the research, there were only two nights on which the observations of the faint stars could be carried on for any length of time. The total number of nights devoted to these observations was but five.

The spectrograph attached to the Breadalbane reflector was, during the first two months of the year, reserved for Nova *Persei*. A plate which had already been exposed twenty-four hours in November of the preceding year was several times inserted again, with the outcome that another two hours were added to the time of exposure in January and February. Unfortunately two occasions in January could not be taken advantage of, because the temperature of the spectrograph differed too much from those on the previous occasions. This plate contains our last record of the spectrum of the new star. On March 3 the spectrum was inspected in the focal plane of the spectrograph without an eyepiece, and it appeared to be reduced to one spot, which, by means of the spark spectrum, was identified as the

principal nebular line. Another line in the neighbourhood of 4480 was noted as doubtful.

In April and May the red and yellow region of the spectrum of *Mars* and the Moon was photographed on ten nights; the plates have not yet been reduced. For the rest of the year work with the spectrograph was suspended; a new triple object-glass for the collimator, f. 10, achromatised from wave-length 5000 to 3700, was supplied in December by Messrs. Steinheil & Sons, and provision was made for automatic heating of the instrument.

A paper containing the discussion of the spectrum of Nova *Persei* as photographed here is now ready for the press.

The time service and meteorological work has been carried on as in former years.

Liverpool Observatory. (*Mr. W. E. Plummer.*)

No change has been made in the staff or in the instrumental equipment of this Observatory during the past twelve months. In the absence of any photographic apparatus, efforts were made in the early part of the year to enable the staff to take some part in the measurement and the reduction of photographic plates taken at other observatories; but though the directors of some observatories were kind enough to send selections of plates for the purpose of measurement, the project fell through owing to the impossibility of securing a suitable measuring machine.

Under these circumstances the series of observations pursued in earlier years has been continued. These include the systematic observation of comets, while bright enough to be observed in the equatorial, the coordinates of a certain number of binary stars, whose choice is also limited by the aperture of the telescope, and other extra-meridional observations.

The Observatory is a meteorological and seismological station, and observations connected with these subjects are zealously pursued. In connection with the routine work may be mentioned the distribution of time signals, the testing and rating of chronometers and other philosophical apparatus for which the Mersey Docks and Harbour Board are prepared to grant certificates of test. With the office of Director of the Observatory is coupled that of Hon. Reader of Astronomy in the University of Liverpool, and under this arrangement lectures are regularly given in the Observatory.

Radcliffe Observatory, Oxford.
(*Dr. Rambaut, Radcliffe Observer.*)

The work with the transit circle during the year 1903 has been confined to observations required to complete the working list of stars and reflection observations for the determination of the R—D correction.

The reduction of the observations has been pushed on vigorously, and all the observations up to date, both in R.A. and N.P.D., have been reduced to mean place.

The preparation of the new catalogue, which will contain the places of stars observed during the ten years 1894–1903, is well in hand. All the observed places have been entered in the catalogue, and checked as far as 1899 February, and approximate mean places for the epoch 1900·0 have been computed. This new catalogue will contain the places of about 1770 stars, and of these the annual precessions and secular variations have been computed and examined for 1041. The remaining 729 are chiefly zodiacal stars.

The Barclay 10-inch equatorial has been used chiefly for observations of new or variable stars and comets. Nova *Aurigæ* was observed on January 2, Professor Wolf's variable in *Cygnus* on October 9, Nova *Persei* on November 25, and Professor Turner's Nova *Geminorum* on March 26 and 30, April 4, 13, 20, and 29, May 4 and 20, and November 25.

Search was made for the comets 1902 *b* (*Perrine*), 1896 V (*Giacobini*), 1903 *d* (*Brooks*), and the position of the first determined with the ring micrometer on February 21 and 23. This instrument was also employed in observing occultations of stars during the lunar eclipse of April 11 and for other miscellaneous observations. (See *Monthly Notices*, lxiii. 7.)

The work of testing and examining the new twin photographic and visual refractor and of getting all the parts into thorough working order has absorbed a large proportion of the time and energy of the Observatory staff during the year. This work has been very much hampered by the unfavourable weather which prevailed, especially during the autumn months. Within two months after being mounted the 24-inch and 18-inch objectives had twice to be taken out of their cells and cleaned in order to remove moisture which had penetrated between the lenses. To avoid a recurrence of this trouble two small condensing gas stoves were erected early in the year in the basement of the equatorial tower, from which the slightly heated air rises into the dome. These have been found to work very satisfactorily, even in cases of extreme humidity of the air.

Other unforeseen circumstances very much delayed the preliminary trials, and it was not till April that it was possible to obtain photographs with the 24-inch. A number of plates were exposed for determining the best separation for the crown and flint lenses and for testing the figure of the objective, but some of the minor fittings of the instrument were much delayed, so that regular work could not be commenced before the end of the year.

Among the objects photographed are the clusters, Pleiades, M 13 (*Herculis*), ♄ VI, 33 and 34 (*Persei*), Præsepe (*Cancri*), ♃ VIII. 8 (*Cygni*), M 38 (*Aurigæ*), and the Moon.

It is intended to commence an investigation of the parallax

of stars in selected regions, according to the method proposed by Professor Kapteyn (*Bulletin de la Carte du Ciel*, tome i. p. 262), and photographs of the fields surrounding B.D. 35°, 4013 and 61 *Cygni* were taken and sent to Professor Kapteyn to enable him to compare them with those already taken by Professor Donner with the astrographic telescope of the Helsingfors Observatory, and discussed by Professor Kapteyn in the *Publications of the Astronomical Laboratory at Groningen*, No. 1.

The focal length of the instrument is 22 feet 6 inches, and it is adapted to carry plates up to 12 inches square. The stellar images appear sensibly circular over a field of $1\frac{1}{2}$ degrees in diameter.

A number of double stars were examined for the purpose of testing the 18-inch objective. Amongst those divided were O.Σ. 175, O.Σ. 234, B.D. 21°, 984, and γ^2 *Andromedæ*, but the bifilar micrometer was not received till the middle of December, and the seeing has been so bad since then that no measures have been attempted.

During the lunar eclipse of April 11 several occultations of stars were observed with this instrument.

Meteorological observations have been carried on as usual, as well as observations of underground temperature by means of platinum resistance thermometers, as in previous years, but it is intended to bring the latter to a close shortly.

University Observatory, Oxford. (*Prof. H. H. Turner.*)

The completion of the work for the Astrographic Catalogue has been prevented by a wholly unexpected failure in sensitiveness in the photographic plates supplied, which is still causing trouble. Only ten plates out of the 1180 are still required, and these have been taken, and could have been measured and reduced, several times over, but on no occasion did they show enough stars relatively to previous plates, owing to some cause not yet fully understood, which seems, however, to be certainly connected with the sensitiveness of the films, and not with either weather or developer. This fault first occurred in 1903 February, when advantage had been taken of a spell of fine weather to take forty or fifty plates, most of which were found on development to fall short of the proper standard. The makers did all they could to rectify the defect, and at once sent us some better plates in substitution; and on this occasion we were more than compensated for the loss of time and trouble by the fortunate discovery of Nova *Geminorum*, which appeared after the defective plates had been taken, but in time to be shown on those which replaced them. But it was no longer possible to get all the plates in the spring, and on July 31 we were in the position of having completely measured and reduced all the plates but twenty-three, which could not be taken till October. The night of October 30–31

being particularly fine, Mr. Bellamy and Mr. Plummer spent the whole night at the Observatory, and were able to report the last plate secured at 5.20 A.M., ten minutes before twilight would have put an end to the work. Unfortunately there was again an unexpected failure in sensitiveness in the plates. The best of them could just be passed for measurement, though none were really good, and ten had to be rejected. These ten are still (1904 January 1) required, for a spell of bad weather has since prevented further exposures. Meanwhile Mr. Bellamy has paid a special visit to the plate-makers (Messrs. Elliott & Son) and discussed the matter with them. It appears that our requirements were not fully comprehended ; the film required for faint and scattered points of light, such as stars, would not be the same as that for bright diffused light, even though very great "rapidity" is required in both cases. It is accordingly hoped that such misadventures may be rarer in future ; but it was a considerable disappointment to the whole staff that we were not able to announce the work complete on December 31. They had worked diligently and loyally to that end, and I should like to record here my recognition of this fact and my sympathy with their disappointment.

The discovery of Nova *Geminorum* naturally brought a little extra work with it. Mr. Bellamy took several plates of the region, one with 100 min. exposure. The positions of 166 surrounding stars were measured and published by him (*Monthly Notices*, vol. lxiii. p. 326, and vol. lxiii. p. 512), and he also measured the region of X *Geminorum*, which occurs on the same plate (*Monthly Notices*, vol. lxiii. p. 526). Photographs taken by Dr. Max Wolf and by Mr. Parkhurst before the outburst indicated a faint star very near the place of the Nova, with which it might be identical ; but careful measures of copies of these plates, kindly sent to Oxford by the owners, threw doubt on the identity, and Professor Barnard has since seen the small star alongside the Nova (*Monthly Notices*, vol. lxiii. p. 565).

The examination of the differences between the places of stars deduced from our measures and the Cambridge meridian observations has been extended to the Declinations. The results are in fair accord with those deduced from the R.A.'s mentioned in the last Report, but an independent discussion threw some doubt on the reality of the systematic proper motions deduced by the former method. It seems probable that these systematic motions are too small to be detected by the indirect method of comparing plates of *different* regions, taken at intervals of five years, with the same meridian catalogue, and we must wait until plates of the same regions can be repeated at a suitable interval (*Monthly Notices*, lxiv. p. 3).

Mr. H. C. Plummer, M.A., in addition to his work in the Observatory, has published three papers in the department of mathematical astronomy ; one on the determination of the elements of an orbit (*Monthly Notices*, vol. lxiii. p. 147), and two on

"Oscillating Satellites" (*Monthly Notices*, vol. lxiii. p. 436, and lxiv. p. 98).

A method of photographing the Moon among the stars was tried and found successful (*Monthly Notices*, vol. lxiv. p. 19), but no systematic work can at present be undertaken in this direction.

The work of reducing the Rousdon Observatory observations of variable stars has occupied much time during the year, but is now completed and nearly printed. Fortunately the discussion of the results has rewarded us by bringing out several points of great interest, which seem worthy of further investigation. By adopting a compendious method of presenting the results it is shown that the characteristic constants can be easily and accurately deduced, and that the formulæ given in Chandler's Third Catalogue can be confirmed or corrected; and it is hoped that a definite step has been taken towards the interpretation of these formulæ.

Seeing that the completion of our work on the Astrographic Catalogue would set free measuring apparatus and experienced measurers, the suggestion was made that we should measure the plates taken at the Perth Observatory, West Australia, for which it had been found impossible to obtain funds from the West Australian Government. But the suggestion was entirely conditional on the provision of funds from some source independent of the University. To make sure that no unforeseen difficulties would arise, Mr. Cooke sent fifty of his plates to this Observatory, and twenty-one of them were measured and compared with the places of the Argentine General Catalogue, the others not being measured at present because it seemed doubtful whether they showed enough stars. For this work a small grant was obtained from the Government Grant Committee of the Royal Society. But a Committee of the Royal Society appointed for the consideration of the whole scheme was not in favour of proceeding further, and the project has therefore been abandoned.

One of the Harvard sky charts of fifty-five plates has been purchased, and is being examined with a view to determine the optical distortion. The investigation, which is in the hands of Mr. Kr. Lows of Christiania, is not yet completed; but the distortion is clearly very small. Mr. J. C. W. Herschel, from counts of star images on the plates, finds that the field is satisfactorily uniform as regards star magnitude (*Monthly Notices*, vol. lxiv. p. 118). Mr. J. H. Metcalf, of Vermont, U.S.A., has photographed the regions of several variable stars and measured the positions of a large number of stars on the plates.

Towards the end of the year Mr. C. L. Brook, F.R.A.S., generously presented to the Observatory one of the beautiful Stereo-comparators made by Messrs. Zeiss, of Jena, from designs by Dr. Pulfrich. It is hoped that valuable results may be obtained by comparison with this instrument of plates of the same region taken at different dates. Mr. Metcalf has already acquired some experience with the instrument.

Temple Observatory, Rugby. (*Mr. G. M. Seabroke.*)

The interest in astronomy has increased in the schools during the past year. Besides the attendance on fine evenings last term, two regular evenings in the week have been given up for instruction in the use of instruments.

An astronomical branch of the Natural History Society has been formed, and they will have the use of the 12-inch reflector for photography of the Moon and micrometer measures.

This work, which is the primary object of the Observatory, prevents much other work being done. It is hoped that some at least of the boys will take away with them a taste for astronomy.

Solar Physics Observatory, South Kensington.
(*Sir Norman Lockyer.*)

Observations of Sun-Spot Spectra.—Although spots were recorded on the Sun's disc on 192 days during 1903, there were only 99 days on which it was found possible to observe their spectra. Altogether the spectra of 130 spots were observed in the F—*b*, *b*—D regions. An analysis of the records shows that the lines generally affected were due to vanadium, titanium, or the "unknown" substances. A paper containing a detailed discussion of the widened lines observed since 1879 will shortly be published.

In addition to observations of widened lines in Sun-spots at South Kensington, those made at the Maharajah Takhtasinghi Observatory at Poona are also supervised, and an analysis of the results obtained there leads to the same general conclusion mentioned above. A photographic daily record of the conditions obtaining on the Sun's visible disc is kept at South Kensington, daily photographs being received from Dehra Dûn (India) and Mauritius. These are mounted as soon as they have been received, and arranged and finally bound in half-yearly volumes. The Mauritian prints are primarily used to fill up the gaps in the Indian record.

In addition to this current record prints are being prepared from the excellent series of negatives obtained by Canon Selwyn, at Ely, between 1863 and 1874, which have been loaned for this purpose by the Royal Society. Of these 1048 prints have been made, of which 859 have been mounted.

The Spectro-heliograph.—After a long series of experiments with an improvised instrument a final form of spectro-heliograph was decided upon, and the parts not already in the possession of the Observatory were ordered from the different makers. Some of these were received and mounted in connection with the 18-inch siderostat at the western end of the Observatory grounds

during October 1902. Further experiments were then carried out to determine the best form for the secondary slit, and a curved slit devised in accordance with the results was ordered from Messrs. Hilger, and received here during May 1903. From May 19 to the end of October a series of good "K" light photographs of the solar disc was obtained. It was, however, found that towards the end of October the low altitude of the Sun, combined with the cloudy and hazy atmosphere and restricted horizon available, prevented photographs being obtained even with greatly lengthened exposures, and it was therefore decided to abandon the attempts until the early spring.

Considerable difficulty was experienced during the exposures from the fact that under the influence of the reflected beam of solar rays the focal length of the 6-inch Taylor photo-visual lens, which is used for producing the image on the first slit, was found to change rapidly. To obtain a photograph showing fine details it was necessary to refocus this lens at the commencement of each exposure. Given a clear sky, photographs showing excellent detail could be obtained with an exposure of thirty seconds; altogether some 200 successful photographs were obtained between May and October.

Stellar Spectra.—Owing to the abnormally bad meteorological conditions of 1903 for photographic work, the absence of the first assistant for some months through illness, and of the second, who has been loaned to the Indian Government for a period of sixteen months, for service at the Kodaikanal Observatory, the amount of night work performed was somewhat below the average. The instruments chiefly used were a prismatic camera, equipped with a 6-inch objective, and a 6-inch 45° objective prism (Henry), and attached to the 10-inch refractor; and a 2-inch prismatic camera fitted with a calcite prism and a quartz objective, and fixed to the side of the 6-inch Dallmeyer equatorially mounted. The spectra of nineteen stars were obtained with the former instrument, several being photographed repeatedly for special investigations. The latter instrument was used for obtaining on a small scale the complete (*i.e.* ultra-violet to red) spectra of pairs of stars, each member of a pair being situated on different horizons of the temperature classification curve. This work was undertaken in order to test the sequence of the stellar groups on the temperature curve previously obtained from the consideration of the various spectra from the chemical standpoint, and the result of the research is very satisfactory. The spectra of each pair of stars to be compared were photographed on the same plate under as similar conditions as possible of atmosphere, exposure, altitude, photographic treatment, &c., and are thus strictly comparable. These identical conditions are difficult to obtain, owing to the sudden atmospheric changes, the different magnitudes, effective actinic qualities, and declinations of the stars, and many exposures had to be made to secure the thirteen successful pairs obtained. Owing to the small staff (now

augmented), and the pressure of other work, the 30-inch reflector and the 9-inch prismatic camera were not in regular use throughout the year; the spectra of several faint stars were obtained with the last-named.

The 36-inch reflector has been undergoing modifications and additions at the hands of Messrs. T. Cooke & Sons, who have fitted it with motors for working the fine adjustments, and a new $3\frac{1}{2}$-inch following telescope with slipping plate and electric illumination for the field. During the readjustment of the instrument some photographs of the nebula in the *Pleiades* and the *Orion* nebula have been obtained.

Meteors.—Arrangements were made for observing the *Perseid* shower, but clouds prevented observations. No organised watch was kept for the *Leonids*, but about 18 were seen during the intervals in other observations on November 14, whilst on the 15th over 50 were seen, and some 30 were charted by one of the observers, Mr. W. E. Rolston, at his residence.

Laboratory Work.—Numerous spectra of terrestrial substances were obtained with the 3-inch Cooke spectroscope, which is mounted on cement piers and kept always in adjustment, ready for immediate use.

The photographs obtained included a number of spectra of the dust which fell in various parts of England during the great dust storm of February 19, 20, and 21.

During the storm on the early morning of May 31 three photographs of lightning spectra were secured by Dr. W. J. S. Lockyer, by means of a 5×4-inch Kodak and an improvised camera, each fitted with a Thorpe transmission grating. To understand these and to determine the origins of the lines a large number of laboratory spectra were obtained with the former instrument similarly adjusted.

To this end the spectra of a high-tension spark, from the large Apps coil, in air, and in air with large excess of water vapour, nitrogen, and oxygen were obtained.

Meteorological Reductions.—The marked accordance found to exist between solar and terrestrial changes rendered it imperative that as complete a record as possible of the meteorological data (*i.e.* more especially "pressure" and "rainfall") obtained from stations situated in every part of the world should be prepared.

For this reason it was found necessary to extract a great amount of data from the various official meteorological records—a great part of which was secured from the Meteorological Office—and to reduce them to convenient forms for the discussion. This work has occupied much of the time of the computing division during the past twelve months, and the great number of curves and tables thus prepared are now available for future work, and form a valuable collection of facts.

Publications.—Two papers dealing with the interrelation of solar, magnetic, and meteorological phenomena were communi-

cated to the Royal Society under the following titles : "On the Similarity of the Short Period Pressure Variation over Large Areas" (*Proc. Roy. Soc.* vol. 71, pp. 134, 135) ; "The Relation between Solar Prominences and Terrestrial Magnetism" (vol. 71, pp. 244–250).

Two other papers on solar phenomena, under the following titles, were also communicated : "Solar Prominence and Spot Circulation, 1872–1901" (*Proc. Roy. Soc.* vol. 71, pp. 446–452) ; "On a Probable Relationship between the Solar Prominences and Corona" (*Monthly Notices*, June 1903, pp. 481–488).

A fifth paper, entitled "The Spectrum of γ *Cygni*" (*Phil. Trans.*, Series A, vol. 201, pp. 205–222), was communicated to the Royal Society.

A number of papers dealing with the reduction of the spectra of various celestial and terrestrial elements, solar and meteorological changes, and the spectra of Sun-spots are nearly ready for publication, whilst further papers on subjects under these headings are being prepared.

Stonyhurst College Observatory. (*Rev. W. Sidgreaves.*)

The meteorological and magnetical continuous records have been carried on as usual, except that the vertical force magnet has been left out of running on account of its defective balance.

A few photographs of the spectra of Sun-spots in the region $\lambda 4958 - \lambda 5140$ have been taken with the large spectrometer, but larger mirrors are required to make the work more efficient.

The solar surface has been observed on 220 days, notwithstanding the unfavourable weather, and 194 drawings have been added to the series, with notes of 13 dates of clear surface. But progress with the stellar spectrographs has been slower than ever.

The spectroscopic study of β *Lyræ* was completed in October, and the results were presented to the Society at the November meeting ; but the reproduction of the spectrograms has delayed the publication till the January number of the *Monthly Notices*.

The astronomical instruments of the late Colonel Cross's Observatory at Redscar have been presented to the Stonyhurst Observatory by his son, the present squire. The smaller of two equatorial polar axes, built for a 7-inch Newtonian reflector, has been mounted in a revolving shed, and is intended to carry the 4-inch prismatic camera as soon as some difficulties connected with the clock-driving have been overcome. The two spectrographs will then be in operation together, one on the Perry equatorial for the blue and yellow regions, and the prismatic camera for the violet and ultra-violet spectrum.

Mr. Edward Crossley's Observatory, Bermerside, Halifax.

Owing to the bad health of the observer, Mr. Gledhill, very little work was done at this Observatory in the year 1903 beyond the usual metereological observations.

Wolsingham Observatory (Rev. T. E. Espin).

The work of measuring double stars has been continued, as in the previous years. Fifteen new pairs detected during the year have been communicated to the Society.

Sir William Huggins's Observatory, Upper Tulse Hill.

The photography of the spectra of stars and nebulæ, which has been in progress for some years, has been continued during the past year.

Experimental work in the laboratory has included the photographing of the spectrum of the spontaneous radiation of radium-bromide, and its recognition as identical with the negative pole band spectrum of nitrogen.

Rousdon Observatory, Lyme Regis, Devon.
(Late Sir C. E. Peek's ; C. Grover, Observer in Charge.)

The building and instruments are maintained in good working order. The year as a whole has been distinctly unfavourable for astronomical work. The six months April to September were the best half of the year. December was abnormally cloudy ; during the sixteen days 9th to 25th the Sun by day and the stars by night were scarcely visible. Observations were made on 148 nights. The 6·4-inch Merz equatorial has been used in the observations of long-period variable stars, and 460 magnitude determinations have been made. Argelander's method has been followed, as during the previous seventeen years. At each observation the light of the variable is estimated relatively to five comparison stars in the same field of view, the mean result being assumed to be the magnitude on the date of observation. About twenty-five long-period variables are under regular observation, and, as most of these are circumpolar in this latitude, their light changes are continuously recorded.

Transits of stars are taken as often as required for the regulation of the sidereal clock and mean-time chronometer.

Considerable attention was given to the planet *Mars*, and seventeen sketches were made between March 10 and May 8. Power 310 was mostly used, and, as at former oppositions, many

of the well-known features of the planet as figured by Green and Knobel in the *Memoirs of the R.A.S.* were very well seen.

The eclipse of the Moon on April 11 was observed under very favourable weather conditions.

Borrelly's Comet (*c* 1903) was observed on thirteen nights between July 7 and August 22. Toward the end of July it was distinct to the naked eye, and in the telescope the tail was a long straight ray, with a fainter ray from each side, giving it a decidedly fan-shaped aspect.

The transit of *Jupiter's* fourth satellite was observed on November 16, when the satellite appeared on the disc of the planet as a perfectly black, well-defined, circular spot.

Dr. Isaac Roberts's Observatory, Crowborough Hill, Sussex.

The following list includes the nebulæ, clusters, &c., which have been photographed during the year 1903. In spite of the abnormally great rainfall the year showed a perceptible increase in the number of fine nights, as compared with its predecessor. The month of December, however, was a marked exception, the sky being persistently overcast during the greater part of it. Two photographs were obtained of Borrelly's comet, on July 24 and 26, which showed a remarkable change in the structure of the tail in so short an interval.

List of the Principal Photographs taken in 1903.

	Approx. R.A. h m	Decl. ° ′	Expos. h m
Neb. H III. 147 Andromedæ ...	0 5	+25 22	1 30
Neb. H V. 16 Andromedæ ...	0 13	+29 31	1 30 (two)
Index Cat. 11 Cassiopeiæ ...	0 15	+55 2	0 51
Neb. *h* 17 Piscium	0 16	+21 53	1 30
Neb. *h* 29 Andromedæ ...	0 28	+47 57	1 30
Neb. M 31 Andromedæ ...	0 37	+40 43	0 57 1 30 2 15
Neb. M 33 Trianguli	1 28	+30 9	1 30
Neb. H II. 282 Ceti	1 30	− 7 51	1 30
Neb. H II. 438 Ceti	2 16	− 5 59	1 30
Neb. H II. 619 Arietis ...	2 54	+24 50	1 30
Neb. *h* 2522 Eridani	3 15	−19 47	1 30
Nebulosity near the *Pleiades* ...	3 44	+25 16	2 58 4 0 (two)
Neb. H II. 514 Tauri... ...	4 31	− 0 21	1 30
Neb. H II. 457 Eridani ...	4 43	− 5 37	1 30
Neb. H III. 447 Orionis ...	5 23	− 5 24	1 1
Neb. *h* 356 Orionis	5 24	− 8 28	1 30

	Approx. R.A. h m	Decl. ° ′	Expos. h m
Index Cat. 423–4–6 Orionis ...	5 28	− 0 32	1 30 (two)
Neb. M 42 Orionis	5 30	− 5 27	0 15 1 30
Index Cat. 427–8 Orionis ...	5 31	− 6 38	1 30 (two)
„ „ 430 „ ...	5 33	− 7 8	1 30
H's Nebulous Region No. 27 ...	5 43	+ 1 8	2 44 2 57
N.G.C. 2175 Geminorum ...	6 3	+20 30	1 30
Neb. H IV. 20 Monocerotis ...	6 6	− 6 11	1 30
Index Cat. 443 Geminorum ...	6 10	+22 30	1 30 (two)
Neb. H II. 726 Cancri ...	8 4	+34 15	1 30
Neb. H IV. 55 Lyncis ...	8 5	+46 18	2 51
Neb. H III. 710 Lyncis ...	8 7	+49 23	1 30
Neb. H II. 719 Lyncis ...	8 7	+36 34	1 30
Neb. H III. 599 Cancri ...	8 22	+21 49	1 30
Neb. H II. 727 Lyncis ...	8 38	+35 4	0 58
Neb. H II. 80 Cancri ...	8 43	+19 27	1 30
Neb. H II. 823 Ursæ Majoris ...	8 50	+51 44	1 19
Neb. H II. 490 Lyncis ...	9 3	+33 32	1 30
Neba. H I. 56–7 Leonis ...	9 26	+21 57	1 30
Neb. H I. 168 Ursæ Majoris ...	10 12	+41 55	1 30
Neb. H III. 700 Ursæ Majoris ...	10 33	+42 11	1 30 2 0
Neb. H II. 362 Leonis Minoris ...	10 46	+28 30	1 30
Neb. H III. 20 Leonis	10 47	+10 41	1 30
Nebæ. M 65, 66, &c., Leonis ...	11 14	+13 50	1 30
Nebæ. H I. 227–8 Ursæ Majoris ...	11 39	+56 43	1 30
Nebæ. H I. 248, 251 Ursæ Majoris ...	11 46	+60 36	1 30
Groombridge 1830 Ursæ Majoris ...	11 47	+38 27	0 15
Neb. H V. 51 Draconis	12 12	+70 1	1 30
Neb. M 99 Virginis	12 14	+14 59	1 30
Neb. H V. 43 Canum Venaticorum ...	12 14	+47 51	1 30
Neb. H I. 75 Comæ Berenicis ...	12 15	+30 10	1 30
Neb. H V. 29 Comæ Berenicis ...	12 21	+34 5	1 20 2 0
Neb. M 88 Virginis	12 27	+14 58	1 30
Nebæ. M 58, 59 Virginis	12 35	+12 22	1 30
Neb. H I. 84 Comæ Berenicis ...	12 45	+26 3	1 30
Neb. M 94 Canum Venaticorum ...	12 46	+41 39	1 0
Neb. H I. 134 Virginis	12 49	− 9 59	1 30
Cl. M 53 Comæ Berenicis	13 8	+18 42	0 30

	Approx. R.A. h m	Decl. ° ′	Expos. h m
Cl. M 3 Canum Venaticorum	... 13 37	+28 53	0 30
Neb. H I. 181 Boötis... ...	... 13 53	+42 20	2 0
Neb. H I. 190 Boötis... ...	... 13 54	+37 54	1 30
Cl. M 5 Libræ	... 15 13	+ 2 27	0 30
Cl. M 13 Herculis	... 16 38	+36 39	0 15 0 30
Cl. M 92 Herculis	... 17 14	+43 15	0 30
Neb. *h* 1989 Herculis... ...	... 17 47	+23 6	1 0
Cl. M 18 Clypei	... 18 14	−17 11	0 30
N.G.C. 6643 Draconis ...	... 18 22	+74 31	1 30
Cl. H VIII. 12 Aquilæ ...	... 18 31	− 8 19	0 30
Cl. M 26 Aquilæ	... 18 40	− 9 30	1 30
Neb. M 57 Lyræ	... 18 50	+32 54	0 10 0 20
Cl. H VII. 18 Vulpeculæ ...	... 19 39	+23 4	0 30
Cl. *h* 2048 Cygni	... 19 39	+39 57	1 0
Milky Way in Cygnus ...	... 19 45	+35 30	1 0
Neb. M 27 Vulpeculæ ...	... 19 55	+22 27	1 0 (two)
Cl. M 75 Sagittarii	... 20 0	−22 13	1 0
Cl. H VII. 59 Cygni	... 20 0	+43 43	1 0
Cl. M 29 Cygni	... 20 20	+38 12	1 0
Neb. H V. 15 Cygni	... 20 42	+30 21	2 55
Nebulosity in Cygnus... ...	... 20 45	+31 20	1 45
Cl. M 72 Aquarii	... 20 48	−12 55	1 0
Neb. H V. 14 Cygni	... 20 52	+31 19	2 5
Neb. H III. 858 Equulei ...	... 21 10	+ 2 25	2 0
Cl. H VII. 50 Cygni	... 21 21	+47 36	0 50
Cl. M 15 Pegasi	... 21 25	+11 44	0 30 (two)
Neb. H II. 247 Delphini ...	... 21 56	+17 16	1 30
Neb. H II. 1 Aquarii... ...	... 21 57	−21 18	1 30
Cl. H VI. 29 Cephei	... 22 11	+53 50	1 0
Neb. H IV. 31 Aquarii ...	... 22 27	−14 38	1 0
Neb. H II. 705 Cephei ...	... 22 36	+60 46	1 0
Neb. H II. 429–30 Piscium ...	... 23 9	+ 3 48	1 30
Neb. H II. 467 Piscium ...	... 23 11	+ 6 8	1 30
N.G.C. 7571 Pegasi	... 23 12	+18 26	1 30
Neb. H II. 236 Aquarii ...	... 23 13	− 5 12	1 30
Neb. H III. 473 Pegasi ...	... 23 19	+16 12	0 48
Neb. H III. 213 Pegasi ...	... 23 27	+15 18	1 30

Comet *c* 1903 (Borrelly) 45^{m} (July 24), and 60^{m} (July 26).

Mr. Saunder's Observatory, Crowthorne, Berks.

With the assistance of Mr. J. A. Hardcastle, F.R.A.S., progress has been made in the measurement of some of M. Lœwy's negatives of the Moon. Four plates in all have now been measured, giving an average of about 400 points on each. The constants of three of these plates have been found, and the reductions are in a forward state, though one plate only has been completed. Standard positions are being gradually built up for the points most frequently measured, and the probable error in the value of a co-ordinate as derived from a single plate is thus found to be about 0″·13. This work is being accomplished with the aid of a grant made by the Government Grant Committee of the Royal Society.

With the telescope some progress has been made with the minute study of special formations on the Moon, but the atmospheric conditions have prevented much work in this direction. The lunar eclipse of 1903 April 11 was observed, and the diameter of the white spot surrounding Linné was measured immediately before and after its passage through the shadow. The diameter was found to have increased 0″·50±0″·195 during the interval, very closely agreeing with an increase of 0″·55 found by Professor W. H. Pickering at Harvard, although Professor Pickering's value of the final diameter was only 3″·34, whilst the measures made at Crowthorne gave 6″·05, showing a difference of 2″·71.

Daramona Observatory, Streete, Westmeath. (*Mr. W. E. Wilson.*)

The weather during the past year prevented any work being done in the Observatory. The rainfall amounted to 45·72 inches, which is about 10 inches above the average for the last twenty-five years. In the month of March, which is generally a good one for clear skies, rain fell on every day but one. In the laboratory some experiments were made on the effect of pressures up to 300 atmospheres on the absorption spectrum of certain liquids. The mirrors of the 2-foot reflector and also of the large heliostat were re-silvered.

Abbassia Observatory, Cairo. (*Capt. H. G. Lyons.*)

During 1903 the work of the Observatory has been carried on upon the same lines as during the preceding three years, the reorganisation having taken place from the beginning of 1900. The Observatory is under the general direction of Captain H. G. Lyons, the Director-General of the Survey Department, and the

superintendent is Mr. E. B. H. Wade, who is assisted by a staff of five.

The work of the Observatory is chiefly meteorological, in which section hourly observations have been made of the temperature, atmospheric pressure, relative humidity, vapour tension, wind velocity and direction, and sunshine. Of these the atmospheric pressure is registered by a Sprung-Fuess balance barograph, the wind velocity by Dines's pressure tube recorder, the wind direction (provisionally) by Denza's recorder, and the other elements by Professor Callendar's electrical recorder. Eye observations three times a day are also made of barometric pressure, temperature, relative humidity, vapour tension, state of the sky, direction and velocity of the wind, rainfall, evaporation, actinic intensity, and underground temperature.

Observations are also made with the transit instruments on every fine night for rating the standard clocks for the purposes of the daily time signal. The Observatory is also occupied with the standardisation of instruments for sending to meteorological stations in Egypt and in the Soudan, fourteen of which are now furnishing daily telegraphic reports of the weather to the office of the Survey Department, Giza. Magnetic observations are made weekly at Helwan, twenty-three kilometres from Cairo, with a Kew set of instruments, and determinations of atmospheric electricity with a portable electrometer are made at the same time. A continuous record of earth tremors is furnished by Milne's seismograph.

During the year twenty occultations have been observed with the 21-cm. Brünner equatorial. The Observatory is also responsible for the astronomical observations required for the triangulation of the country and their computation.

This Observatory is being transferred to a new site, about fifteen kilometres south of Cairo and on the desert plateau near the town of Helwan.

Kodaikanal Observatory. (*Prof. C. Michie Smith.*)

The director having left India on furlough on October 31, 1902, the Observatory was put under the charge of Mr. C. P. Butler, who arrived at the station on January 3, 1903. He had received special instructions to arrange for the routine observation of Sun-spot spectra as early as possible, and with this object a spectroscope was specially put together from parts of others at the Observatory, none of the original instruments being of sufficient power for the purpose. This was first mounted on the old Lerebours and Secretan equatorial of six inches aperture, and later on the six-inch Cooke refractor, the latter being preferred on account of its being provided with a position circle, which is necessary for the measurement of prominences at the Sun's limb.

It was necessary for some time to observe the spectra in duplicate, as the assistants had had very little experience in this class of work, but after becoming familiar with the difference between subjective and objective widening of the lines they quickly became efficient observers, and from the middle of the year they have been entirely responsible for the duty, although the supervision was kept up from time to time.

Sun-spot Spectra.—It appears from the results obtained that the spectrum of Sun-spots during the year has been practically identical with that recorded for the past few years at other institutions, and no evidence of variation has been detected. The lines observed are due chiefly to titanium, vanadium, scandium, and some unknown element or elements. The solar activity showed a marked increase during the year, and spectrum observations were obtained on 114 days.

Prominences.—Wherever the sky was clear enough the positions of all prominences visible at the limb were measured, and the position-angles recorded were at once reduced to solar latitudes.

Eight-inch Solar Pictures.—No. 4 Dallmeyer photo-heliograph was taken to pieces and thoroughly overhauled. After re-erection and adjustment several plates were taken for focussing, and afterwards a photograph has been taken on every day when the weather has permitted. These are almost always taken early in the morning, as the sky generally becomes hazy about 9·30 or 10 A.M., rendering further observational work impracticable.

Photographs of Sun in Monochromatic Light.—An instrument had been ordered for obtaining photographs of faculæ, &c., consisting of a spectro-heliograph on the Hale-Deslandres plan, with an 18-inch Foucault siderostat to supply the light to the spectroscope, a 12-inch Cooke photo-visual objective being provided for forming the image on the primary slit. The building for this was got ready, but the spectro-heliograph, which was promised in August, had not been received at the end of the year. The 18-inch siderostat was safely received and erected. This is working, and the work can be started as soon as the spectroscopic equipment is received from England.

Photographs of the Sun-spot Spectra.—A few plates were taken of the large spots in March, but the dispersion at the direct focus was much too small, and the work was discontinued until the arrival of the long focus lenses which have been ordered for the purpose.

Time Observations.—The transit instrument was got into use for this work, but the almost general clouding of the sky before noon rendered it impossible to use this method regularly, and during the greater part of the year the chronometers and clocks have been rated from sextant observations of the Sun in the early morning. As a check time signals are received from the Madras Observatory at 4 P.M. each day. For some time these have been quite useless, owing to their being retransmitted by hand

at intermediate stations. By the kindness of the telegraph authorities this has now been remedied, and a *through* circuit installed, making the signals in every way reliable.

Meteorology.—Complete records of meteorological observations have been made, as in previous years, and all the instruments have been in good working order throughout the year. The total rainfall for the year was 69·55 inches. The maximum daily wind was 971 miles during the storm of December 4.

Actinometry.—Whenever the sky has been quite free from haze measurements of the solar radiation have been taken with a Balfour-Stewart actinometer, but the number of such days has been very few during the present year.

Seismology.—The Milne seismograph has been in action throughout the year, and the data concerning the chief disturbances forwarded to various authorities, as in former years.

Magnetic Observations.—The underground magnetic vault has been repaired considerably, to exclude the damp, which had begun to seriously affect the instruments. The cases of the magnetographs have been hermetically sealed to the pillars and drying agents put inside. By these precautions the evil has been considerably lessened, but constant attention has been necessary. The records have been regularly obtained during the year, but the constant illness of the observers has caused inconvenience by the frequent changes.

Very good records were obtained of the great disturbances of October 12 and 31; in the latter case the deflection was so great that the spot of light went off the paper. The mean values of the observed elements are as follows:

Mean Westerly Declination	= 0° 22′·1 (W.)	1903.
Mean Inclination or Dip	= 3° 5′	
Mean Horizontal Intensity	= 0·37369 C.G.S.	

Melbourne Observatory. (*Mr. P. Baracchi.*)

Meridian observations were made with the 8-inch transit circle, and are as follows:

	R.A.	N.P.D.
Clock stars	476	...
Circumpolar stars	323	106
List stars	1300	1299
Heliometer comparison stars	549	552
Total	2648	1957

The list stars were, as in previous years, selected from the Photographic Catalogue plates to serve as fundamental stars for the reduction of these plates. The total number now completely

observed three times or more is 4481. The heliometer comparison stars were observed at the request of Sir David Gill, and completes his list published in April 1901. These observations have been fully reduced, and will shortly be forwarded to the Cape Observatory. The separate results and annual catalogue for 1902 have been prepared. The reduction of all other meridian observations are well advanced.

Astrographic Operations.—

Chart plates with triple exposure of 30^m each	146
Catalogue plates (duplicate series)	99
Test plates on south polar regions	40
Test plates on Oxford type regions	12
Test plates for centre, focus, trails, &c.	31

Eighteen chart plates and three catalogue plates were rejected as defective.

The state of the work to 1903 December 31 is as follows :

Chart plates with triple exposure of 30^m each, passed as satisfactory	372
Chart plates with single exposure of 60^m each ...	Complete
Catalogue plates	Complete
Catalogue plates (duplicate series)	235

Since using filtered water for developing, and drying in practically dustless air, the chart negatives obtained show a very decided improvement.

Terrestrial Magnetism.—In addition to the usual routine of photographic registration and absolute measurement of the magnetic elements, the full programme in regard to terrestrial magnetism prescribed by the Royal Society and Royal Geographical Society for co-operation with the Antarctic expeditions, which was to have terminated in March 1903, was, at the request of these societies, continued throughout the year, and will not be concluded till next March.

Further progress has been made in the measurement and reduction of the magnetic curves of the past thirty-five years. This work is now complete to January 1894.

The Milne seismograph has been kept constantly at work. Reprints of the more important seismograms have been prepared, and the whole of the results so far obtained are being prepared for transmission to the Seismological Committee of the British Association.

Other Observatory work which has been carried on as usual for public local requirements comprises—

The Time service.

The Tide service.

The Weather service, with control of some 800 recording stations.

The installation and routine of the State Standards of Weights and Measures service, now in charge of this Observatory.

Rating of chronometers for the shipping, testing, surveying, and meteorological instruments, also a large number of air-meters for mining inspectors.

Sydney Observatory. (*Mr. H. C. Russell.*)

The first portion of the year the Astronomical branch was under Mr. Lenehan, but during the latter part his time was taken up with administrative work and assisting Professor O. Klotz, of the Ottawa Observatory, Canada, in the work he was deputed to do in determining the longitudes of the stations touched by the Pacific cable and generally throughout the world.

Another astronomer of note, Professor Hussey, was credited to Mr. Russell, who had instructions from the New South Wales Government to do what he could to further his mission, *i.e.* to find for the committee under the presidency of Professor Lewis Boss, of Dudley Observatory, if they could establish an astronomical station in New South Wales, Professor Hussey to report if the conditions of the climate would be suitable, &c.

In this work the Government placed Red Hill Observatory, with its assistant, under Mr. Hussey's immediate control. The report of this visit will, of course, be first placed with the American authorities, and a copy later will be forwarded to the Observatory. It may be mentioned that both these American astronomers expressed their gratitude for the ready assistance given.

Unfortunately the director, Mr. H. C. Russell, C.M.G., F.R.S., was taken with a severe illness, and most of the duties devolved on Mr. Lenehan.

During the latter part of the year rain and cloud interfered with the astronomical work, and the computers during the time were busy reducing previous observations.

Number of	R.A. observations	... ...	2644 stars
„	N.P.D. „	... ...	2431 „
„	Observations of R.A. of Sun...		446

making a total of 3090 R.A. observations.

The 9 A.M. collimations, 310 ; level, 309 ; nadir, 306. 9 P.M. level, 143 ; nadir, 134 ; azimuth determinations, 133.

Mr. Raymond, the assistant observer, had charge of the reduction of stars to January 1, and has the work well in hand. 1901 is ready for the printer, and has gone to swell the mass of observations awaiting necessary funds for publication. A new catalogue for overlapping astrographic plates has been computed,

and the astrographic work under Mr. Short at the Red Hill Observatory is in the following state :

Number of plates required to complete two sets of catalogue plates, 3. Number on original list, 1400.

Plates required to complete three sets of chart plates, 59 ; number on original list, 654.

Plates required to complete one set of overlapping plates, 950 ; number on original list, 1078.

The equatorial has not been used for double-star work during the year, as the observers were taken up with transit observations for central stars for the astrographic plates, which are urgently required.

Much of the officials' time has been absorbed attending to visitors, many of whom are only sightseers and have no scientific interest in looking over the Observatory. The number of visitors who attended during the year was 792.

This Report must not be closed without the expression of thanks to those officers in the Observatory for the very hearty way they have fulfilled their duties, and so helped in the general welfare of the institution.

Especial credit is due to Mr. Masters, who has helped by his aptitude and great constructive ability the work of instrumental repairs and construction.

Measurement of the Plates of the Astrographic Catalogue. Joint Report for Sydney and Melbourne.

The measurement of the plates of the Photographic Catalogue for the Sydney and Melbourne zones was carried on at the Melbourne Observatory under the same conditions as stated in previous Reports.

After March 31 the actual measuring was continued on a reduced scale by three measures only, as it was considered desirable to check for a short interval the rapid accumulation of material, the amount of which had already assumed large proportions, in order to commence the preparation of the work for publication.

During the year 1903 the errors of three réseaux and methods for determining photographic magnitudes were investigated, and 219 plates, containing 63,861 stars, were completely measured. The total number of plates completely measured in two positions up to 1903 December 31 are :

224 Sydney plates, containing 131,061 stars.
512 Melbourne plates, containing 147,343 stars.

The new measuring machine, constructed at the Sydney Observatory, and described in *Monthly Notices*, vol. lxiii. p. 39, has been installed at the Melbourne Observatory for the use of the Measuring Bureau. It reached Melbourne only a few days ago, and has not yet been tested, but the results of a preliminary trial

made at Sydney appear satisfactory. The Measuring Bureau was installed since the beginning of the year 1903 in a new spacious room built especially for the requirements of this class of work and the convenience of the observers.

Perth Observatory, Western Australia. (*Mr. W. E. Cooke.*)

Astrograph.—This year was unfortunate in some respects. A legacy of uncertainty as to the intentions of the Government with respect to the astronomical work was bequeathed from the previous year, and it was not until February 24 that authority was obtained to order any fresh plates for the astrograph. A cablegram was immediately despatched to England for one gross, and another gross was indented in the usual manner. Unfortunately, owing to departmental delays, this second order was not sent until June 1, and the regular supply of plates did not recommence until September. The weather, too, was remarkably cloudy throughout the winter and spring months. On the whole, therefore, progress with the international work has not been so rapid as might have been wished. Altogether 281 catalogue plates were taken and passed as satisfactory. The present state of this undertaking is as follows :—

Chart plates (three exposures of 30^m each) ...	42
Catalogue plates	406

The work is now again in steady swing, and it is hoped that substantial progress may be made during the present year. The measurement of the plates cannot be commenced at the Observatory, owing to the manner in which the vote for purely astronomical purposes has been restricted ; but the Royal Society has made a grant of 100*l.*, and the plates are being sent to Oxford, where Professor Turner has kindly offered to do the best he can with this grant.

Transit Circle.—Steady progress has been made with the standard stars for the catalogue plates. The portion assigned to the Observatory includes 32°–40° South declination. In 1902 32° and 33° were practically completed, and in 1903, at the request of Sir David Gill, 39° and 40° were undertaken. This overlaps his zones, which will enable the results to be compared. During the present year this zone work will be discontinued, and the various constant errors, such as errors of graduation, variation of personal equation for magnitude, &c., will be investigated. As a result of a few observations already made it appears probable that the errors of graduation amount in some places to as much as 3″ for the mean of four microscopes, and a systematic determination is imperative.

During 1903 the following observations were made :

Level error	202
Azimuth error...	293
Collimation error	27
Meridian mark	29
Nadir point	137
Flexure	8
Observations of R.A. (zone stars)	4085
„ N.P.D. „	4094
„ R.A. (clock stars)	937
„ N.P.D. „	11

Field Work.—Hitherto there has been nothing in the nature of an astronomical survey of the State, but the Observatory has now commenced to cooperate with the Lands Department, and during the year the positions of Coolgardie and Albany were determined by the Government Astronomer. The only available field instrument was a 12-inch theodolite, and the method adopted for obtaining time and latitude was the one described in the *Monthly Notices, R.A.S.*, for January 1903. This has proved to be a very valuable method, and results of a high order of accuracy can be obtained with a comparatively small instrument.

In fact, whilst waiting for the erection of a pillar at Albany, a 6-inch theodolite, on which a sensitive bubble had been mounted, was used, and the results were practically as good as with the 12-inch. It is confidently believed that with a 6-inch theodolite, provided with a sensitive level and suitable reticle, and a portable chronograph (or chronometer), the result of one clear night's observation would not be likely to be 1″ in error in either coordinate.

Meteorological.—The ordinary work has been continued and the forecasts have been as successful as usual. Their general usefulness is very much restricted, owing to the lack of means for their distribution.

The forecast which appears in the daily morning paper, for instance, is issued at 4 P.M. on the previous day, and it may happen that an anticipated storm, &c., is already in progress when the public read their paper. This condition, however, will gradually improve as population increases and means of intercommunication become more rapid. The percentage of successful results was as follows :

	Correct.	Partially Correct.	Wrong.
General forecast for the State, issued at noon ...	94	4	2
„ „ „ 4 P.M. ...	93	6	1
Special for the Goldfields, issued at noon ...	94	5	1
„ „ „ „ 4 P.M. ...	91	6	3

	Correct.	Partially Correct.	Wrong.
Special for the Murchison, issued at noon ...	95	3	2
„ for Perth and neighbourhood, issued at 9 A.M.	95	4	1

In addition two special storm warnings were issued to North-West ports, and these were amply justified by subsequent events. There were no other storms in that district during the year.

Publication.—The annual meteorological report for 1902 has been delayed, but is now practically ready for publication, and will be issued very shortly. Funds will not at present permit of any astronomical printing, but the observations are all reduced, and will be finally checked during the present year; and it is hoped that some means will be found for publishing the results of zones 32°, 33°, 39°, and 40° before very long.

Lovedale Observatory, Cape Colony. (*Dr. A. W. Roberts.*)

As in previous years the work done in 1903 was strictly confined to the observation of variable stars south of −30° Declination.

The number of stars under observation, and the number of observations made during the year, are as follows:

	Stars.	Observations.
Algol variables	6	164
Rapid variables	2	185
Short-period variables	22	478
Long-period variables	68	1227
Suspected variables	6	18
Total	104	2072

The total number of observations, 2072, is considerably under the number usually secured—a result chiefly due to the unfavourable observing weather which prevailed during the greater part of the year.

The loan of the Oxford wedge photometers, received about the beginning of the year from Professor Turner, has to be gratefully acknowledged. They are being used to determine the brightness of the comparison stars, to which the various variable stars under observation are related.

Mr. Tebbutt's Observatory, the Peninsula, Windsor, N. S. Wales.

Very little work having been done during the last three months, the report here given really applies to the first nine months of the year. The following is the work in each department:

Meridian Department.—

Nights on which local time was determined		86
Transits of stars with a declination not exceeding 40°		374
Transits of stars of high declination for azimuth		73
Separate determinations of	level error	238
	collimation error	25
	azimuth error	64

Extra-Meridian Department. — The following micrometer comparisons were made with the 8-inch equatorial :

Objects Compared.	Nights of Observation.	Number of Comparisons.	Number of Comparison Stars.
(17) Thetis	5	77	1
(29) Amphitrite	4	45	2
(324) Bamberga	23	236	10
Comet 1902 III. (Perrine)	13	159	13
Comet 1903 III. (Grigg)	16	138	18

The observations of Comet 1902 III. were a continuation of a series commenced in 1902, and referred to in the last Report. On April 21 a telegram appeared in the *Sydney Morning Herald* announcing the discovery of Comet 1903 III. by Mr. John Grigg, of Thames, New Zealand, but without furnishing any positions, and it was not till April 25 that I received a letter from the discoverer giving rough places for April 17 and 18. By these means I was enabled to observe the visitor. The first four positions secured were cabled to Kiel, from which an approximate orbit was computed by Dr. Kreutz and Herr Ebell.

In addition to the work reported above, the usual daily rainfall and maximum and minimum monthly temperature observations have been carried on throughout the year.

Notes on some Points connected with the Progress of Astronomy during the Past Year.

Discovery of Minor Planets in 1903.

Forty-one new planets were discovered, or first announced, in 1903, as follows :

Provisional Designation.	Permanent Number.	Date of Discovery.	Discoverer.	Place of Discovery.
LA	500	1903 Jan. 16	Wolf	Heidelberg
LB	501	„ „ 18	„	„
LC	502	„ „ 19	„	„
LD	...	„ „ 18	„	„
LE	...	„ „ 18	„	„
LH	...	„ „ 31	Dugan	„
LJ	...	„ Feb. 6	Wolf	„
LK	504	1902 June 30	Bailey	Arequipa
LL	505	„ Aug. 21	Frost	„
LM	...	„ Oct. 21	„	„
LN	506	1903 Feb. 17	Dugan	Heidelberg
LQ	508	„ Apr. 20	„	„
LR	509	„ „ 28	Wolf	„
LS	...	„ „ 20	„	„
LT	510	„ May 20	Dugan	„
LU	511	„ „ 30	„	„
LV	512	„ June 23	Wolf	„
LW	...	„ „ 30	„	„
LX	...	„ July 1	„	„
LY	...	„ Aug. 24	„	„
LZ	...	„ „ 24	„	„
MB	...	„ „ 24	„	„
MC	...	„ Sept. 20	„	„
MD	...	„ „ 20	„	„
ME	...	„ „ 20	„	„

Provisional Designation.	Permanent Number.	Date of Discovery.	Discoverer.	Place of Discovery.
MF	...	1903 Sept. 20	Wolf	Heidelberg
MG	...	,, ,, 20	Dugan	,,
MH	...	,, ,, 22	,,	,,
MK	...	,, ,, 24	Wolf	,,
MM	...	,, ,, 30	,,	,,
MN	...	,, Oct. 20	Dugan	,,
MO	...	,, ,, 20	,,	,,
MP	...	,, ,, 20	,,	,,
MQ	...	,, ,, 20	Wolf	,,
MR	...	,, ,, 25	Dugan	,,
MS	...	,, ,, 27	Wolf	,,
MT	...	,, ,, 27	,,	,,
MU	...	,, ,, 27	,,	,,
MV	...	,, ,, 27	Wolf–Götz	,,
MW	...	,, ,, 27	Wolf	,,
MX	...	,, Nov. 14	,,	,,

The following planets, unnumbered at the date of the last Report, have since received permanent numbers : JG 488, JM 489, JP 490, JQ 491, JR 492, JS 493, JV 494, KG 495, KH 496, KJ 497, KU 498, KX 499.

The following planets do not receive permanent numbers, not having been sufficiently observed : JT, JW, JX, JY, JZ, KA, KB, KC, KF, KL, KM, KN, KO, KP, KQ, KR, KS, KT, KV, KW, KY, KZ, LD, LE, LH, LJ, LM, LS, LW, LX.

Planet JO, to which the number 489 was first assigned, proves to be identical with 470 *Kilia*. The number 489 has been transferred to JM.

The following identities have been established : 483 with CP, 488 with CR, KD with 66 *Maia*, 498 with FF, LF with EM (this has been numbered 503), LG with 360, LO with DE (this has been numbered 507), LP with 406, MA with 184 *Deiopeia*, ML with 214 *Aschera*. A planet photographed at Washington in December 1903, and subsequently observed visually there, is probably identical with DW. An object designated MI was subsequently found not to be a planet. MV may be identical with 316 *Goberta*.

The following planets have been named : 357 *Ninina*, 360 *Carlova*, 368 *Haidea*, 383 *Janina*, 395 *Delia*, 396 *Æolia*, 456 *Abnoba*, 458 *Hercynia*, 462 *Eriphyla*, 482 *Petrina*, 483 *Seppina*, 484 *Pittsburghia*, 488 *Kreusa*, 491 *Carina*, 493 *Griseldis*, 503 *Evelyn*, 507 *Laodica*.

Numerous photometric observations of 433 *Eros* were obtained at Arequipa during last year's opposition, but the results are not yet published. This planet will next be in opposition in August

1905, when it will be of the 12th magnitude, in 12° S. Decl., the circumstances resembling those at discovery in 1898.

M. O. Callandreau published some statistics of the orbit elements of minor planets in *Comptes Rendus* for April 20. He arranged them in groups according to increasing aphelion distance, finding that for the inner group (mean aphelion distance 2·4) the mean eccentricity is 0·075 and inclination 4°, while the corresponding quantities for the outer group (mean aphelion distance 3·9) are 0·212 and 8°. A. C. D. C.

The Comets of 1903.

To the account of the comets given in the last Annual Report it may be added that Giacobini's Comet, discovered on December 2, and remarkable for its great perihelion distance, remained visible till June 26, on which date it was observed at Mount Hamilton. The comet had then so dwindled in brilliancy as to be compared to a 13th-magnitude star, with a nucleus which was estimated at the 16th magnitude. Comet 1902 III. (but during the earlier observations having the designation *b* 1902), on its return from great Southern Declination, was first reobserved on January 29, and followed with difficulty, on account of increasing faintness, till March 23. On April 27 no trace of the comet was visible in the 36-inch refractor of Mount Hamilton. The orbit is parabolic.

The first comet of 1903 was discovered on January 15 at Nice, by M. Giacobini, in *Pegasus*. The motion was north-east and the brilliancy increasing. Consequently the comet soon became a conspicuous object, and in the middle of February was described as bright as the *Andromeda* nebula. At the time of greatest brilliancy, about March 16, the comet was too near the Sun for observation. Photographs were taken at Greenwich and elsewhere, but the position was unfavourable. After perihelion passage the comet became visible in the Southern Hemisphere, and was observed at the Cape of Good Hope till May 4. This orbit does not differ sensibly from a parabola.

On April 16 a comet was discovered by Mr. Grigg, of Thames, New Zealand, which was observed by Mr. Tebbutt at Windsor, N.S.W. The comet had passed perihelion on March 25, and was growing fainter. The apparent path of the comet did not permit it to be observed in the Northern Hemisphere. Observations were secured at Windsor and at the Cape of Good Hope till May 28. The only elements published appear to be those of Drs. Kreutz and Ebell, and the material on which they are founded is too rough to decide the exact character of the orbit.

On June 21 M. Borrelly, of Marseilles, made the third comet discovery of the year. This comet, found in *Aquarius*, and tolerably bright, was moving northwards and increasing in brilliancy, so that it became readily visible to the naked eye. It was

repeatedly photographed, and the structure and behaviour of the tail have been adequately described (*Lick Observatory Bulletin*, No. 47). On the examination of a photograph showing the passage of the comet over a tolerably bright star, Dr. Max Wolf, of Heidelberg, satisfied himself that the constituents of the comet had exercised selective absorption on the star's light (*Ast. Nach.*, No. 3914). The perihelion passage happened towards the end of August, when the comet became invisible, being too near the Sun. Towards the middle of September, when the brilliancy had declined to about that which the comet exhibited at the time of discovery, it stood in the Southern Hemisphere, and was observed at the Cape up to October 22. An attempt was made to trace the comet on plates taken at Harvard on May 28, and also on some taken at Arequipa on the 4th of that month. The question of possible earlier observation does not seem to be decided, but a suspicious object noted on the Harvard plates was probably not the comet. The possibility, however, of earlier detection by the photographic method, when the previous course of the comet has become known by the determination of approximate elements, possesses a distinct interest.

These are all the comets that can be said to have been discovered, but on August 20 Mr. Aitken, of the Lick Observatory, found Brooks's (1896, VI.) Comet, for which Dr. Neugebauer had computed an accurate ephemeris from the observations made at previous returns. The correction to this ephemeris was +22 sec. in R.A., and +1′ 41″ in Declination, which could apparently be removed by a slight alteration in the time of perihelion passage. Mr. Aitken describes the comet as faint and small, irregular in outline, and with but feeble condensation. The greatest diameter did not exceed 3′, and the brightness about equalled that of a 14th-magnitude star. This comet was followed at Lick till October 24, growing continually feebler in illumination and increasingly difficult to observe. Other observations are not known.

This was the only periodic comet whose return was successfully observed. Several other comets have probably passed through perihelion without detection. This list includes Brooks's Comet (1886, IV.), which should have returned to the Sun about March 25, but, as the comet was not seen either in 1892 or 1897, the error in its assigned position may be considerable. The circumstances for its observation were slightly more favourable than in those years, but the uncertainty of its position was necessarily greater. Perrine's Comet (1896, VII.), according to the calculation of Dr. Ristenpart, passed through perihelion on April 26, but the angular distance of the comet from the Sun always remained small till about November, when its brightness would have dwindled to about one-sixteenth of that when last seen in 1897. No observations have, therefore, been possible, and this is the more to be regretted since an accurate determination of the mean motion was most desirable, in order to decide whether

this comet has had any connection in the past with the well-known comet of Biela. Spitaler's Comet (1890, VII.) was due at perihelion in August last, but the elements are now very uncertain, as it was not observed at its return in 1897. Giacobini's Comet (1896, V.), for which Dr. Ebell prepared sweeping ephemerides, based on a period of 6·647 years, has likewise passed undetected, though sought for in the great telescope of the Lick Observatory. Faye's Comet, that has been so regularly observed at each returning perihelion passage, has proved disappointing. Its observation would have been specially interesting, since the comet has in its last revolution made a close approach to *Jupiter*, with the result, according to Dr. Strömgren, that the mean motion has been altered from 468″ to 480″, and the date of perihelion consequently accelerated by four months. On June 3 it was near perihelion, but the earliest chance of detection was at the latter end of August. Dr. Aitken was, however, unable to see any trace of it. Of D'Arrest's Comet, the calculations concerning which are in the hands of M. Leveau, it may be mentioned that the brilliancy has passed its maximum, and that, considering the unfortunate position in which it is placed, its redetection is practically hopeless. Winnecke's Comet is not in perihelion till January 21 of this year, but the ephemeris prepared by Dr. C. Hillebrand has hitherto proved fruitless.

Recent Researches on the Theory of Comets' Tails.

The mystery of cometary emanations has given rise to many researches during the last few years. Most of the recent writers on this subject have made use in some way or other of Maxwell's idea of *radiation-pressure*; Maxwell * observed that if light be regarded as an electromagnetic phenomenon, the mere incidence of light on an absorbent material body ought to cause a pressure on the body, measured by the amount of electromagnetic energy resident in unit volume of the region just in front of the body. This fact of radiation-pressure has been discussed since from the theoretical side by Bartoli,† Boltzmann,‡ and Larmor §; while from the experimental side its existence has been established by Lebedew,‖ and Nichols and Hull.¶ A reflecting body, of course, experiences the pressure to an even greater extent than an absorbent one.

Although electricity has been in one way or other connected with cometary emanations by various writers, the first close approach to the view now so largely held seems to have been made in 1881 by Faye,** who, speaking of the repulsive power exercised by the Sun on comets, said "J'ai tenté, il y a longtemps,

* *Elect. and Mag.* §§ 792–3.
† *Exner's Rep.* xxi. (1885), p. 198.
‡ *Wied. Ann.* xxii. (1884), p. 31.
§ *Æther and Matter* (1900), p. 130.
‖ Paris Congress (1900), *Reports on Physics*, ii. p. 133.
¶ *Astroph. Journal*, xvii. (1903), p. 315.
** *C. R.* xciii. p. 362.

de la rattacher à l'état d'incandescence du Soleil." A year later a definite theory was formulated by Fitzgerald.*

Fitzgerald, starting from Maxwell's expression, suggests light-pressure as the cause of comets' tails, and determines the size of a molecule of gas of given density in order that it may be neither attracted nor repelled by the combined effect of the Sun's light-pressure and solar gravitational attraction; observing that each different kind of gas would give rise to a separate tail, since the size and density of the molecules of different gases would not be the same. He seems, however, to have taken the light-pressure as due solely to absorption, and notes † the difficulty caused by the fact that gases absorb only a very minute proportion of the radiations that fall on them, and so (on his assumptions) will experience only a slight light-pressure.

Fitzgerald's hypothesis was again brought forward by Lebedew ‡ in 1892, and by Arrhenius § in 1900. Arrhenius, however, makes the modification of supposing that the matter repelled by the light-pressure is not gaseous, but consists of fine particles which have condensed from the gaseous emanations of the comet.

The next step was taken by Schwarzschild,‖ who observed that Arrhenius's conclusions were insecure, inasmuch as the particles repelled must be so small as to have dimensions comparable with the wave-length of light, and the magnitude of the light-pressure would therefore be profoundly altered by the effects of diffraction. Accordingly he investigated the problem of the diffraction of an electromagnetic wave round a perfectly conducting sphere (the effect of radiation-pressure will, of course, be greatest when the repelled particles are perfectly reflecting); and then applying Maxwell's formula for the pressure in terms of the electric and magnetic forces, he obtained the total average pressure on the sphere. The result shows that when the dimensions of the particles are either small or large compared with the wave-length of the incident light, the pressure is small compared with the gravitational attraction; but for intermediate values of the radius of the sphere, the pressure may play an important part.

Assuming that the radiation-energy of the Sun is partitioned among the various wave-lengths according to the law given by Wien for a perfect radiator (which, as Langley has shown, is to a first approximation correct), Schwarzschild comes to the final conclusion that light-pressure is sufficient to account for a repulsive force possibly as much as twenty times that of gravity on cometary appendages, but is not a possible explanation of greater repulsive forces than this. This result is really a difficulty in the

* *Proc. Roy. Dub. Soc.* part vi. vol. iii. (1882).
† *Electrician*, December 14, 1900.
‡ *Wied. Ann.* xlv. p. 292.
§ *Öfversigt af Kongl. Vet.-Ak. Förhandlingar* (1900), p. 545.
‖ *Munich Sitzungsberichte*, 1901, p. 293.

way of the light-pressure theory, for W. H. Pickering,* from observations of Comet 1892 I., obtained a solar repulsive force 39·51 times the attraction of gravitation, and Hussey† found in the case of Comet 1893 II. a repulsion 36 times that of gravitation.

It only remains to notice three other theories of comets which have appeared in late years.

Fessenden‡ puts forward the view that the tail consists of material particles carrying charges of negative electricity, and moving under the influence partly of the Sun's gravitation and partly of electrostatic forces, due respectively to a negative charge supposed to exist on the Sun, a positive charge on the comet's nucleus, and the negative charges on the other particles of the tail.

J. J. Thomson§ remarks that if the comet's nucleus when heated by the Sun's rays gives off negative ions, these ions would be repelled by the Sun's radiation and appear as a luminous tail behind the comet. On performing the calculations, however, it appears that the repulsion exerted on an ion by ordinary light-rays would be very slight, and the effect must therefore be caused by Hertzian waves emitted by the Sun, if such exist. There are two difficulties in the way of this theory—namely, that it is doubtful whether the nucleus is likely to be heated to the temperature required for emission of the ions, and that no Hertzian radiation from the Sun has hitherto been detected, although search has been made for it. Thomson does not give his view on these matters; we may, however, get over the first of the difficulties by supposing that the emission of ions is due, not to the heating of the nucleus, but to the incidence of the Sun's ultra-violet light on it; and the second cannot be regarded as fatal until it is known whether Hertzian waves from the Sun are absorbed in the upper regions of the Earth's atmosphere.

Lastly, Boys‖ suggests that the presence of radio-active substances in the nucleus may be the cause of cometary appendages. If we further suppose the Sun to have an electric charge, the rays, after leaving the nucleus, would be turned back by the electrostatic field so as to form a tail, and indeed the different types of rays which radio-active substances are known to emit would give rise to tails of different curvatures.

E. T. W.

Progress of Meteoric Astronomy in 1903.

Quadrantids.—Very windy and stormy weather occurred at the period of these meteors, and at Bristol on January 3 there was frequent lightning during the night. The sky was, how-

* *Annals of Harvard Coll. Obs.* vol. 32. † *Publ. Ast. Soc. Pacific*, 1895.
‡ *Astroph. Journ.* iii. p. 36 (1896). § *Phil. Mag.* iv. (1902), pp. 253–62. Presidential Address to Section A of the British Association, 1903.

ever, clear at many places on January 2 and 3. On the former date there was little evidence of the *Quadrantids*, but on January 3 they formed a well-marked though not unusually rich shower. Maximum on morning of January 4. The radiant as determined by six observers was :

	α.	δ.	↓s.		α.	δ.	↓s.
Astbury	228°	+53½°	6	Denning	228°	+53°	7
Besley	228½°	+51½°	6	A. S. Herschel	229°	+52°	9
Brook	222°	+50°	8	King	228°	+52°	8

Lyrids.—The shower returned on April 21 and 22, but it was not strongly represented. On April 18, 19, and 20 there was scarcely any sign of its activity. On April 21 and 22 Professor Herschel at Slough watched during a total period of 7¾ hours and saw 47 meteors, of which 19 were *Lyrids*, radiant 270°+35°. On April 21 and 22 Mr. King at Leicester watched for 5¾ hours and noted 51 meteors, including 19 *Lyrids* with radiant 271½° +33°. On April 19 at Bristol observations were made between 11h and 14h 30m, but meteors were scarce, only 12 being seen, including 2 doubtful *Lyrids*. At 13h 40m a fine meteor, 3×4, with a thick yellow train, moved in 4½ secs. from 157°+60° to 73°+60½°, directed from a radiant at 218°−31°.

Mr. R. M. Dole, of Jamaica Plain, Mass., watched for *Lyrids* on April 18, 19, and 20. 53 appear to have been observed, and 20 other shooting stars. 44 *Lyrids* were recorded on April 20, 12h to 15h. There seemed to be 3 radiants, the richest near α and the others near ζ and β. It is, however, highly probable that many of the meteors supposed to have been *Lyrids* really belonged to contemporary radiants in the same region. April meteors shooting from *Lyra* or its vicinity are not always true *Lyrids*, any more than that November meteors directed from the "Sickle" are invariably real *Leonids*.

May Aquarids.—Mr. G. M. Knight, of Hampstead, observed about 25 of these bright, long-pathed meteors on April 30, May 1, 2, and 3. The radiant was at about 330°±0°. 18 of the meteors were equal to or surpassed stars of the 1st magnitude, and several of them were observed in daylight at about 16h. The motions were slow, colour generally orange, and fine trails were left along their extended flights. Another radiant of less brilliant objects was detected at 302°+23°.

Perseids.—Moonlight greatly interfered with this stream. The earliest meteors of the shower were detected on July 21 in America, and the display did not wholly cease until fully a month later. The maximum apparently occurred on August 12. Mr. R. M. Dole observed the shower at Jamaica Plain, Mass., and found it less numerous than in 1902. On August 12, 11h 20m to 15h 44m (local time), he counted 111 meteors, and thought the average about 29 per hour. The *Aquarids* were well seen by him

on July 28 from a radiant at 338°—14° (12 ↓s). Professor Herschel at Slough noted 25 meteors on August 12, $10^h\ 45^m$ to 14^h, and the radiant appeared to be double. On the same night at Bristol *Perseids* were seen to be fairly abundant and pretty bright, but the gibbous Moon hindered the display from being really conspicuous.

Mr. King at Leicester maintained watches on 18 nights between July 13 and August 21, the time employed being twenty-four hours, during which 130 meteors, including 25 *Perseids*, were registered. He saw the first *Perseid* on July 26, and the shower appeared to be extinct on August 19 and 21. As determined by various observers the radiant exhibited its normal easterly drift, the positions being :

	° °	↓s.	
July 21	24+50	8	C. P. Olivier.
23	26+52	6	„
28	33+55	3	„
28	36+56	4	G. F. Paddock.
Aug. 3	34+55½	6	A. King.
4	35+59	...	D. E. Packer.
4	36+57	7	A. King.
11	44+56	16	C. P. Olivier.
12	46+58	20	W. F. D.
12	41+58	8	A. S. Herschel.
	49+61	5	
17	52+56	11	G. M. Knight.
18	56+57	14	„
19	57+60	9	„
20	57+59	5	„

Orionids.—On October 22, 23, and 24, in watches extending over nine hours, Mr. Denning at Bristol recorded 74 meteors, including 14 *ζ Geminids* (99°+13°) and 10 *ν Orionids* (92°+16°). These results corroborate those obtained in the few preceding years, and show that the *ζ Geminids* have apparently displaced the *ν Orionids* as the richest shower of the October epoch.

Leonids.—A tolerably brilliant and somewhat unexpected display of these meteors occurred on the night following November 15, and afforded a partial compensation for the failures in several recent years. Between about 17^h and 18^h bright *Leonids* appeared at the rate of about four per minute. The meteors were not quite so abundant as those forming the shower observed in America on 1901 November 14, when six or seven per minute were counted. The really active phase of the recent return was decidedly brief, for on November 14 and 16 only a few *Leonids*, such as are visible in an ordinary year, made their appearance

The maximum was attained just as the morning twilight (of November 16) interfered, and it was thought possible that at western stations a really brilliant exhibition might have been witnessed an hour or two later. Reports from America, however, indicate that the shower must have rapidly declined after daylight had interrupted observation by English observers. At the Leander McCormick Observatory in Virginia Mr. C. P. Olivier on November 15, 18^h to 19^h G.M.T., counted only 22 *Leonids*,* while from 20^h to 21^h G.M.T. 28 per hour were seen. The following are brief extracts from various observations as to the number of meteors visible on November 15 :

T. W. Backhouse, Sunderland.—$17^h\ 44^m$ to $18^h\ 5^m$. 83 meteors per hour.

C. L. Brook, Meltham.—12^h to $15^h\ 30^m$. 52 *Leonids* seen, but many others escaped notice while the observer was registering paths.

H. Corder, Bridgwater.—17^h to 18^h. About 200 meteors per hour. Following numbers seen :

h	m		h	m	Min.	Meteors.	
16	45	to	17	0	12	24	Imperfect conditions.
17	0	„	17	23	23	61	Fairly clear.
17	23	„	17	33	10	20	„
17	33	„	17	43	10	30	Clear.
17	43	„	17	53	10	26	„
17	53	„	18	3	10	20	Clouding over and dawn breaking.

W. de Cruce, Exeter.—$16^h\ 25^m$ to $17^h\ 10^m$. 108 meteors observed.

W. F. Denning, Bristol.—Hourly numbers seen in a rather contracted field of observation :

h	h	Meteors.	h	h	Meteors.
12	to 13	16	15	to 16	52
13	„ 14	20	16	„ 17	120
14	„ 15	48	17	„ 18	140

42 seen $17^h\ 30^m$ to $17^h\ 45^m$. Probably 4 per min. $17^h\ 30^m$ to $18^h\ 5^m$ from a good position. Maximum about $17^h\ 40^m$.

W. F. A. Ellison, Enniscorthy.—

h	m		h	m		
12	10	to	13	10	5	*Leonids*
13	10	„	14	10	16	„
14	10	„	15	10	36	„
15	10	„	15	25	11	„
15	25	„	15	40	0	„

* About 80 per hour were counted in England during the same hour, but the far more favourable position of the radiant probably accounts for the difference.

Royal Observatory, Greenwich.—About 150 meteors seen. Most prolific time 18^h, about 100 per hour.

J. R. Henry, Dublin.—$11^h\ 25^m$ to $15^h\ 25^m$. 86 meteors registered, including 52 *Leonids*. Between $16^h\ 25^m$ and $17^h\ 55^m$ the rate of appearance seemed 200 to 300 per hour.

Professor A. S. Herschel, Slough.—$16^h\ 15^m$ to $18^h\ 15^m$. Two hours. 180 meteors mapped and counted, and probably as many more were missed. Estimated rate of apparition, 200 to 250 per hour. 9 meteors seen in the minute ending $17^h\ 45^m$.

M. Horner, Taplow.—86 *Leonids* seen during the last hour of darkness.

Rev. S. J. Johnson, Bridport.—Several hundreds of *Leonids*, with the usual streaks and swift motions, passed across the sky.

G. M. Knight, Hampstead.—

Date.	Watch. h h	Meteors.	*Leonids.*	Max. h m
November 13	15 to 18	39	33	17 10
14	„ „	53	45	17 15
15	„ „	120	113	17 30
16	„ „	31	26	17 0

A. King, Sheffield.—$17^h\ 57^m$ to $18^h\ 3^m$. 18 *Leonids*. Hourly rate about 200.

W. H. Milligan, county Down.—$14^h\ 25^m$ to $16^h\ 25^m$ apparent maximum; hourly rate, 80 to 100.

John McHarg, Lisburn.—$13^h\ 20^m$ to $14^h\ 20^m$. 20 *Leonids* seen.

A. G. Moffatt, Swansea.—$16^h\ 30^m$ to 18^h. A brilliant display of large meteors, some green-coloured, the majority, however, electric blue.

R. Service, Dumfries.—$18^h\ 30^m$ to 19^h. 42 *Leonids* observed.

G. C. Thompson, Cardiff.—Watching with a friend for several hours, only about 25 *Leonids* seen. A number of other meteors radiated from *Auriga*.

F. H. Wright, Northampton.—15^h to $15^h\ 30^m$: 30 meteors seen. $15^h\ 30^m$ to 16^h: 60 meteors seen. Afterwards counted about 3 or 4 per minute. Max. $17^h\ 15^m$, near which time 8 or 10 were several times counted in one minute, and 5 or 6 visible in the sky at the same instant.

In America * Professor E. E. Barnard, at Williams Bay, Wisconsin, watched on November 13 in a clear sky from 15^h to daylight, but only a few meteors were observed, and several of these came from a radiant somewhere near *Orion*. On November 14 the sky was partly cloudy and *Leonids* scarce. At $15^h\ 52^m$, however, 5 members of the shower instantaneously appeared within 20° of the radiant. November 15 was cloudy.

* The times given by the American observers are local, and have not been reduced to G.M.T.

C. P. Olivier, at the University of Virginia, obtained results as under :

Date.					Period.	Meteors.	*Leonids.*
	h	m		h m	h m		
November 12	14	35	to	16 18	1 43	14	1
14	12	28	„	17 28	5 0	80	55
15	12	39	„	16 58	4 19	93	78

A large proportion bright, colour orange, some green, and occasionally red.

J. Stebbins, at Illinois, watched on November 14, 13^h to 17^h and saw 29 meteors, of which 20 were *Leonids.*

The following notes prove the comparative rarity of *Leonids* on November 14 and 16 :

Professor Herschel at Slough watched from 12^h 10^m to 14^h 30^m on November 14, and only saw 3 *Leonids.*

Mr. Denning at Bristol on the same night, looking towards the Sickle of *Leo* during the period 17^h to 17^h 45^m, did not see a single *Leonid* Sky unfavourable on November 16, and very few *Leonids* seen.

Mr. King at Sheffield made observations on November 16, 12^h 16^m to 14^h, but only recorded 2 *Leonids.*

The position of the radiant was determined as follows :

		↓s.
Blum, G., Paris...	151½+22½	48
Brook, C. L., Meltham... ...	150½+23	13
Corder, H., Bridgwater ...	149 +22	...
Denning, W. F., Bristol ...	151 +22	33
Herschel, A. S., Slough ...	150 +24	16
King, A., Sheffield	148 +22	10
Knight, G. M., Hampstead ...	149½+23	5
Milligan, W. H., co. Down ...	149 +22	...
Olivier, C. P., Virginia ...	151 +22	78

The *Leonids* were brilliant, though few fireballs were seen. Professor Herschel says that of the 180 meteors he saw, 10 or 15 surpassed fixed stars in brightness, while quite 30 more could be compared with *Sirius* and *Vega.* Mr. Backhouse found 46, out of 67 *Leonids* registered, as bright as, or brighter than, 1st mag. stars. Mr. King says, "The meteors were mostly brilliant, the average mag. being 1 or a little greater."

Geminids.—Mr. F. H. Wright, Northampton, observed 22 short swift meteors on December 14, 6^h to 7^h P.M. Later in the evening they were less frequent. Mr. J. P. Kenyon at Didsbury found the *Geminids* very abundant on the same date, 9^h 30^m to 10^h 30^m, but the number diminished rapidly after the

latter time. Mr. C. L. Brook, watching for five hours on December 11, saw 34 meteors, including about 6 *Geminids*. On December 14 during three hours he recorded 25 meteors, of which 7 were *Geminids*. The radiant seemed a duple one at the points 110°+31° (10 ↓s) and 114°+27½° (6 ↓s).

Detonating Fireball.—On October 3, in the afternoon, a ball of fire passed over Tain, in the N. of Scotland, and apparently descended on the Edderton Hills with a loud explosion, the noise travelling all along the Sutherland mountains, and being heard in the surrounding counties. In the Rogart valley a vibration similar to an earthquake shock was experienced. The fireball does not, however, appear to have been accurately observed, and details are wanting.

The following is a list of the real paths of several bright meteors observed in England during the past year :

Date. 1903.		G.M.T. h	m	Brightness.	Height at First. Miles.	Height at End. Miles.	Length of Path. Miles	Velocity per Sec.' Miles.	Radiant Point. α °	δ °	Observers.
Jan.	3	7	25	1 — 4	60	47	2	16	228	+52	2
	3	12	5	1 — >1	65	49	41	26	228	+53	2
	3	12	59½	1 — < 4	67	54	30	20	227	+50	2
	10	9	30½	⅓ = ☽	63	31	62	18	116	+ 2	10
	13	6	15	4	57	54	200	34	218	+39	3
	14	7	6	2 × ♀	57	54	53	21	120	− 3	8
	25	7	59	4	95	16	125	15	99	+13	4
	28	11	44	5 × 4	62	41	181	20	280	+43	12
April	22	10	36	>1 — 4	70	56	28	19	271	+34	2
	22	12	32½	>1 — ♀	78	43	49	39	269	+32	2
Aug.	12	10	55	4	67	65	50	32	32	+ 4	2
Oct.	23	11	47	1 — 4	75	37	48	21	40	+16	2
Nov.	15	10	18	> 4 — > ♀	79	42	48	36	56	+22	2
	15	13	42	> ♀	72	32	47	23	61	+24	2
	15	13	59	2 × ♀ / −3 × ♀	90	53	64	...	149	+28	3
	15	16	45	4 — ♀	77	52	30	60	151	+25	2
	15	17	14½	4	77	52	30	45	152	+25	2
	15	17	23	4	84	63	27	67	149	+19	2
	15	18	7	>1 — 4	81	60	24	44	151	+23	2
	18	12	44	♀ — ⅕ ☽	75	33	51	33	50	+20	2

There were a number of *Taurid* fireballs observed at the middle of November.

In addition to the radiants already mentioned only a few appear to have been determined. At the April epoch Mr. King observed feeble showers from the points 216°—26° and 256½°

$+37°$, and on August 21 there was an active centre at $3°+25\frac{1}{2}°$, near α *Andromedæ*. At Bristol several tenuous streams were detected during observations in January, May, and October, and the radiants were satisfactorily derived by combining the meteors recorded in previous years.

Years.	Date.	Radiant. α	Radiant. δ	Meteors.	Notes.
		°	°		
1877–1903	Jan. 17–25	143	+38	9	Rapid, white.
1877–1903	Jan. 22–Feb. 1	159	+27	5	Slow, yellow.
1876–1903	Feb. 7–23	75	+41	7	Slow, bright.
1903	May 18–26	248	+29	6	Slow.
1886–1903	May 25–June 4	280	+31	10	Rapid.
1903	June 22–July 1	245	+64	5	Slow.
1877–1903	Aug.–Sept.	47	−11	5	Rapid, streaks.
1900–1903	Oct. 22–23	91	+59	7	V. rapid.
1903	Oct. 22–24	117	+46	6	Rapid, streaks.
1903	„	133	+77	5	Rapid.
1900–1903	Oct. 22–31	59	+49	6	Rapid.
„	Oct. 22–27	32	+19	7	Slow.
„	Oct. 22–23	117	+30	5	Rapid, streaks.
„	Oct. 22–31	29	+36	5	Medium.

Meteorites.—There appear to have been no well-authenticated cases of stonefalls or ironfalls during the year. Several questionable incidents of the kind have been reported in the papers, but they have not survived the test of investigation. For instance an alarming shower of stones was reported as having taken place on 1903 April 29 near St. Clears, Carmarthenshire; but some of the stones were picked up, and on being submitted to suitable examination were found to be palpably of terrestrial origin. A meteorite was said to have fallen near Ellis, in Edwards County, Texas, on 1902 August 16, and to have struck a Mexican sheep-herder named Guise on the head and killed him. On proper inquiries being made, however, the story failed to receive corroboration, and it was probably only a newspaper canard. W. F. D.

Solar Activity in 1903.

Sun-spots and Faculæ.—The development of the solar activity, as evidenced by the number and area of Sun-spots, has been exceedingly striking throughout the past year. In 1901 the days without spots were 81 per cent. of the total number, and in 1902, after the minimum was past, they were still 72 per cent. But this number in 1903 fell to about 20 per cent., and these spotless days were chiefly confined to the first half of the year.

There was not a single day without spots in the month of July, which was the first month of which this could be stated since November 1898. Later on in the year there was a yet longer period of unbroken activity, namely, from October 1 to December 24. The development of the faculæ has been greater still, and the proportion of days on which there were no conspicuous groups has fallen considerably below 10 per cent.

The progress towards greater activity has been on the whole very steady, but has shown a certain pulse, due to the circumstance, always characteristic of a period of revival, that the increasing activity is at first manifested chiefly in certain longitudes. Periods of greater or less spot frequency, in length about a fortnight each, have therefore alternated with each other, according as the more disturbed or more quiescent hemisphere has been turned towards us.

Allowing for this apparent pulsation, there was a slow and steady increase in the numbers and area of spots, from the beginning of the year up to March 21, when a period of very considerable activity set in, lasting till April 14—a period of twenty-five days—during which the mean daily spotted area amounted to 500 millionths of the Sun's visible hemisphere. This was followed by a short time of quiescence and a gradual rise until the active month of July. August and September were relatively quiet months, but with the beginning of October a very different state of things commenced. A large regular spot was seen on the east limb on October 2 in the northern hemisphere. On October 4 a small regular spot appeared in the southern hemisphere, and proved to be the forerunner of an exceptionally fine group—larger even than the great group of September 1898, and therefore the largest seen since January 1897. This was much the largest group of the year, and was rendered still more interesting by the great and frequent changes which took place in it, and by the considerable magnetic disturbance which occurred when it was about one day past the central meridian. From this time to the end of the year there was a constant succession of interesting and important groups. Of these the most remarkable in one sense was the group seen from October 25 till November 5, which passed the central meridian fifteen hours after the commencement of the greatest magnetic storm experienced for thirty years. Other very striking groups were those occurring from October 30 to November 11, and from November 4 to November 17; the first a succession of regular spots in the northern hemisphere, the second a long stream in the southern hemisphere, which underwent a striking series of changes. Both groups returned to the visible hemisphere during December.

The distribution of the spots in latitude has been strictly that usual at this stage of the solar cycle, nearly all the groups lying between latitudes 15° and 25° in either hemisphere. During the first six months of the year the groups were nearly equally

divided between the two hemispheres. During the last six months, and especially during the last three, the southern groups have shown a decided predominance.

The distribution of faculæ in latitude has changed somewhat since 1902, there being a distinct falling off in the proportion of groups observed in higher latitudes than 40°. E. W. M.

The Prominences.—During the past year a very marked revival of activity has set in, the mean number of prominences observed at Kenley having risen from 5·38 per diem in 1902 to 7·55 per diem in 1903, the former figure being the lowest recorded since the last Sun-spot maximum in 1893.

From observations made on 89 days in 1902 and 88 days in 1903 the following figures are derived for the two hemispheres:

	1902, per Diem.	1903, per Diem.
North hemisphere	... 2·69	3·64
South „	... 2·69	3·91
Total mean number ...	... 5·38	7·55

A more detailed analysis of the observations shows that there were two well-marked zones of activity in each hemisphere, quite symmetrically situated with respect to the solar equator, one between the parallels 20° and 30° and the other between 50° and 60°.

This distribution is much like that of 1902, excepting that the zones between 20° and 30° north and south, which were barely indicated in that year, have increased over fourfold in activity; whereas of the high latitude zones only the northern one shows any noticeable increase, and both have remained precisely in the same latitude as before, viz. +50° to 55° and −55° to 60°. Not the smallest tendency is shown to approach the poles, and the region from 65° to the pole in each hemisphere has remained quite barren of prominences.

A rapid advance of the high latitude zones of activity towards the poles may be expected, however, during 1904 and 1905, judging by the course of events twelve years ago. The final closing in of the high latitude prominences over the poles took place last about the epoch 1894·7, or one year after the spot maximum had been passed.

If injections of sodium and magnesium into the upper chromosphere and prominences be taken as an index of solar activity the past year shows a very great advance over 1902, when the lines of these elements were observed on only two occasions during 89 observing days. Last year, with 88 days of observation, nineteen "metallic" prominences were noted, of which ten were seen north of the equator and nine south.

Of the ten northern metallic prominences, eight appeared between the limits +18° and +28° in latitude and 190° to 260° in longitude—a region characterised by the outbreak of spots

and of an extensive range of calcium "flocculi" during June; and later by the large northern spot and accompanying flocculi of October and November.

Most of the southern metallic prominences were also in this same region of longitude, and between 24° and 30° south latitude. The most active eruption observed was on November 16 at 9 A.M., over the great southern spot-group then on the west limb. The hydrogen lines in this prominence showed intensely bright needle-like projections on each side, indicating violent motions in the line of sight. J. E.

The Rotation of Saturn.

An important addition has been made during the past year to our knowledge of the rotation and, incidentally, the physical condition of *Saturn* through the apparition of a number of bright spots in a somewhat high northern latitude (+36°) of the planet. The history of these spots is not uninteresting. They were first detected by Professor E. E. Barnard with the 40-inch refractor of the Yerkes Observatory. One of them was seen as early as June 15, but it was not until June 23 that it could be reobserved and its position accurately determined, when the discovery was announced by telegraph. A second accurate observation was obtained on the following night. Quite independently, and before he had heard of any spot having been observed elsewhere, Mr. W. F. Denning, on the night of July 1, detected another bright spot, which was followed by a dark mass, with his 10-inch reflector at Bristol. The bright spot was also observed on the same night by Señor J. Comas Solá at Barcelona with a 6-inch refractor. The observations soon showed, in fact, that there were actually quite a number of these white spots, all situated in about the same latitude, though the one first discovered seems to have been more conspicuous than any other.

A comparison of his observations of June 23 and 24 satisfied Barnard that the rotation period must be decidedly longer than $10^h\ 14^m$ (*A. J.* 547), but the first published announcement respecting the rate of rotation appears to have been made by Dr. K. Graff, of Hamburg (*A. N.* 3883). This astronomer derived a rotation period of $10^h\ 39^m{\cdot}01$ from a comparison of observations of the Barnard spot made on the nights of June 23, June 26, and July 4, a period that at first seemed improbably long.

Nevertheless subsequent observations showed it to be substantially correct, and several observers soon published confirmatory results. Thus Comas Solá from his own observations of the same spot found a period of $10^h\ 38^m{\cdot}4$ (*A. N.* 3894). Denning published a preliminary list of observations of this spot in the *A. N.* 3900, from which he inferred that the rate of motion was consistent with a rotation period of $10^h\ 38^m$, the mean of

seven other spots giving $10^h\ 39^m\ 21^s{\cdot}1$; whilst Herr L. Brenner, from his own observations at Lussinpiccolo, stated that the period was exactly $10^h\ 38^m$ (*The Observatory*, 1903, p. 391).

All the foregoing results were more or less preliminary, but some more definitive determinations have since been announced. A long list of observations of the spot first discovered, extending to the end of August, was published by Dr. H. C. Wilson in *Popular Astronomy*, 1903, p. 445, and from these he derived a rotation period of $10^h\ 38^m\ 4^s{\cdot}8$, a result which would seem to be very near the truth. Professor G. W. Hough, from a discussion of a few micrometrical measures of the Barnard spot, finds a variable motion, the rotation period being $= 10^h\ 38^m\ 18^s + n \times 0^s{\cdot}1856$, where $n =$ the number of rotations since June 27 (*Monthly Notices*, lxiv. p. 124) ; whilst three observations of another spot gave a period of $10^h\ 38^m\ 30^s{\cdot}5$. But Hough's results have been disputed by Denning, in a paper published in the *Monthly Notices*, lxiv. p. 239, who strongly questions the correctness of some of the former's identifications. It is obvious that correct identification of the observations is of chief importance in work of this kind, and it is necessary to bear in mind that in the present case the spots were really quite numerous, and that none of them seems to have possessed any permanent characteristic feature by which it might be recognised by its appearance ; whilst, to add to the difficulty, the spot originally detected by Barnard was of large area, was somewhat indefinite, and sometimes had the appearance of being double. Hence it is easily seen that mistakes in identification could easily be made where there are only a few observations available. In the paper last mentioned Denning enumerates nearly fifty observations of the Barnard spot, and the gaps are so slight that it seems difficult to suppose that any serious mistake in identification can have been made by him. From these observations a period of $10^h\ 38^m\ 3^s$ was found for the spot in question for the interval between the latter part of June and the middle of September, a result very close to that found by Wilson. The mean period from about fifteen bright and dark spots from July to December is stated to be $10^h\ 37^m\ 56^s$.

It is fortunate that there can be no doubt whatever as regards the most important fact resulting from the recent observations, notwithstanding any possible differences of opinion there may be on the subject of identification. The spot first detected by Barnard must, from all accounts, have been of extraordinary brilliancy during the first two or three weeks of its existence, so that there is no uncertainty as to the reality of the remarkably long rotation period of about $10^h\ 38^m$; and this fact is a very important one, since the previous determinations of this element, all relating to lower latitudes, are clustered about a period of $10^h\ 14^m$. Moreover in the *Monthly Notices*, xviii. p. 72, will be found two observations by Dawes of a bright spot in the southern hemisphere of *Saturn*, estimated to be in about 40° or

50° S. latitude. These observations, as has been pointed out by Denning (*Knowledge*, 1903, p. 271), indicate a rotation period of about $10^h\ 24^m$, or at any rate one considerably longer than that of the equatorial markings. It seems clear, therefore, that we have on *Saturn*, as on *Jupiter*, a great equatorial current having an enormous velocity in the direction of the planet's rotation relative to the extra-equatorial surface material. But the velocity of this current on *Saturn* is almost incomparably greater than it is on *Jupiter*, amounting as it does in miles per hour to between 800 and 900, as compared with the 250 miles an hour of the latter planet. The important bearing of the recent observations on our knowledge of the physical condition of *Saturn* can be judged from this. It may be inferred for one thing that the surface material of the planet is in a more mobile state than that of *Jupiter*, a circumstance that had already been foreshadowed by the earlier observations, and which is, perhaps, not unconnected with the lesser density of the planet. A. S. W.

Double Stars.

As in former years the work has been classified under the two heads "Observation" and "Calculation." Abbreviated titles have been used as follows :

M. N. : Monthly Notices, R.A.S.
A. J. : Astronomical Journal.
L. O. B. : Lick Observatory Bulletin.

Observations—

R. T. A. Innes. *M. N.* lxiii. 7. Measures of 250 southern pairs made with the 18-inch refractor at the Cape Observatory in the year 1902.

Royal Observatory. *M. N.* lxiii. 7. Measures of some 340 pairs made with the 28-inch refractor at the Royal Observatory, Greenwich, in the year 1902.

Rev. T. E. Espin. *M. N.* lxiii. 3. Measures of 38 new double stars. In most of these the larger star is 8th or 9th mag. ; the comes 8th to 13th mag. The distances vary from 5″ to 18″. Reflector, $17\frac{1}{4}$-inch.

S. W. Burnham. *M. N.* lxiii. 7. Discovery of a close comes to Σ 1594, position-angle 318°, distance 1″·6. There is a note on measures of Σ 1594, and also on the double 31 *Leonis*.

J. L. Scott. *M. N.* lxiv. 1. Measures made with a 5-inch refractor at Hong Kong in the years 1902–3. There are 26 stars under 2″ separation, and 40 between 2″ and 3″.

John Tebbutt. *M. N.* lxiv. 1. Measures of 60 southern pairs in 1902. Good series of *α Centauri*, *γ Centauri*, and *γ Coronæ Australis*.

Royal Observatory. *M. N.* lxiii. 3. Occultation of *ω Leonis*.

E. E. Barnard. *A. J.* 546. Measures and discussion of *Krueger* 60.

Miller and Cogshall. *A. J.* 546. The Berlin zone (20°–25°). Observers noted a number of doubles when taking the meridian observations. Messrs. Miller and Cogshall with the 24-inch Lowell refractor have measured 60 of these pairs, of which three are under 1″ separation.

Eric Doolittle. *A. J.* 547. Measures of 227 doubles, mainly Burnham stars, made at the Flower Observatory in the years 1900–1–2.

W. J. Hussey. *L. O. B.* 40. Measures of 32 Otto Struve stars. These are mostly difficult pairs, for which observations were required.

W. J. Hussey. *L. O. B.* 44. Measures of some miscellaneous stars in the catalogues of Herschel, Hough, Burnham, and others. The Burnham measures are already in Yerkes I. A set of *Sirius* gives 1903·16, 120°·0, 5″·97.

Calculation—

W. Bowyer. *M. N.* lxiii. 6. Discussion of measures of Σ 2525, showing that the motion is orbital—a provisional orbit—period 306 years.

J. E. Gore. *M. N.* lxiii. 3. On the Sun's stellar magnitude and the parallax of binary stars. Results are very accordant. From *α Centauri* the Sun's magnitude comes to −26·31, from *η Cassiopeiæ* −26·65, from *ξ Ursæ Majoris* −26·34.

R. G. Aitken. *L. O. B.* 36. Orbit of *ε Hydræ* AB, the close Schiaparelli pair, period 15·7 years.

W. J. Hussey. *L. O. B.* 32. Parallax of *δ Equulei*.

J. E. Gore. *Knowledge*, 1903 September. "Stellar Satellites." A discussion of the magnitudes, motions, distances from each other of various systems.

T. Lewis. *Observatory*, No. 334. "The Size of Stellar Systems."

T. Lewis. *Observatory*, No. 328. "Some Interesting Double Stars." Σ 13, Σ 39, Σ 86, Σ 262. T. L.

Variable Stars.

The work of discovery of variable stars has gone on apace since last Note, at least sixty-three new variables having been announced in 1903. It would seem useless giving the particulars of every one of these, as they are almost all contained in the *Astronomische Nachrichten*, Nos. 3846 to 3920. The following remarks occur: No. 3, 1903, *Ursæ Majoris* has the extraordinarily short period of $4^h\ 0^m\ 12^s{\cdot}8$, the changes at minimum being very rapid. The variables of shortest period hitherto known are two stars in the cluster *ω Centauri* and *S Antliæ*. The periods of these all exceed 7^h. No. 18, 1903, *Ursæ Minoris*,

is the well known comes to *Polaris*. Variation stated by Jost to be from $8^{m}\cdot5$ to $9^{m}\cdot6$, but brought forward with reserve. The light curve of 19, 1903, *Lyræ*, discovered by Williams, resembles those of *Y Lyræ* and *UY Cygni*. Nos. 23 to 28 are "suspected" only. Nos. 32 to 54 in the great nebula in *Orion* were discovered by Professor Wolf with the "stereo-comparator." No. 55, 1903, *Cygni* is *Algol* type. No. 59, 1903, *Cygni* is, according to Professor Pickering, not a Nova, but a variable.

One of the most remarkable events of the year in this branch of astronomy was the discovery of Nova *Geminorum* (14, 1903), by Professor Turner, at Oxford, on March 16. The circumstances are peculiar. One of the few plates needed for the completion of the zone for the astrographic survey had been exposed on the region in question, and subsequently rejected on account of erroneous setting. The Savilian Professor chanced shortly afterwards to compare the plate with others, and it was found that the cause of the erroneous setting was that the telescope had been set on the Nova. The position is given as R.A. 6^{h} 37^{m} $48^{s}\cdot86$, Dec. $+30°$ 2′ 39″ (1900·0); magnitude at time of discovery 6·8. Since then the star has faded steadily, it being $8^{m}\cdot70$ on 1903 March 26, $9^{m}\cdot42$ on May 20, and was found at the Radcliffe Observatory, Oxford to have fallen to $11^{m}\cdot99$ at the end of the year.

The outburst of this star must have been fairly rapid, for according to the Harvard photographs it was, if present, less than $11^{m}\cdot4$ on March 1 and less than $9^{m}\cdot5$ on March 2. It first appears on March 6 as of $4^{m}\cdot97$, falling to $8^{m}\cdot08$ by March 25.

The spectrum of the star showed the hydrogen lines $H\alpha$ and $H\beta$ very bright, at the Potsdam and Yerkes Observatories. Professor Barnard observed that the focus did not differ appreciably from that of the comparison stars; but a beautiful crimson image, undoubtedly due to $H\alpha$, was found a little outside the proper focus for the Nova.

Nova *Persei*, 1901, seems to have been fading slowly but steadily. It is now (January) about 10^{m}.

A great extension of our knowledge of the spectra of faint stars is now rendered possible by the application of the Crossley reflector of the Lick Observatory to this purpose. With a spectroscope built specially for this telescope photographs can be taken of stars below the 15th mag. It is obvious a huge and unworked field of research lies before such high optical power, especially among the long-period variables.

The work of observation of variable stars at Harvard College Observatory has been carried on during the past year with the energy characteristic of the director, Professor E. C. Pickering, who, we learn, made his one-millionth photometric setting on 1903 May 25.

We must note the appearance of "A Provisional Catalogue of Variable Stars" issued from Harvard College Observatory. This contains 737 stars. Until the issue of the Catalogue of the

Astronomische Gesellschaft it will doubtless be the leading authority.

The "Fifth Report of the Section of the British Astronomical Association for the Observation of Variable Stars" has been published as vol. xi. part iv. of the *Memoirs*. It contains the results of some 7504 observations, made principally in the three years 1900–1902; also diagrams of the light curves of a number of stars of short and long period, and of *Algol* type, as deduced from the observations.

Mr. Gore has lately called attention to the possible *secular* variation of the light of the stars. When examining Al-Sufi's *Description of the Fixed Stars*, written in the tenth century, he noticed certain stars which seemed to have either increased or diminished in light. As the magnitudes given by Al-Sufi are probably those of Hipparchus this takes us back over 2000 years in time. It is an interesting subject; unfortunately mathematics cannot be brought to bear on it, as in the case of gravitation, and hence these possible changes can only be substantiated by an accurate photometric record extending over centuries.

The extensive series of observations of variable stars made at the late Sir C. Peek's observatory will be edited by Professor Turner, and published shortly in the *Memoirs* of this Society.

Mr. A. S. Williams has published in our *Monthly Notices* an interesting account of the light curve of *UY Cygni*. The maximum is pointed, the rise from minimum to maximum being extremely rapid, while after maximum the declension of light is slow.

Mr. A. W. Roberts has also an important paper on the light curve of a close binary system. The typical system may be considered as consisting of two stars, equal in size and brightness, spherical in figure, revolving round each other in, or nearly in, contact, in an orbit whose plane lies in the line of sight. Infinite variations may be introduced by changes in the relative size, shape, and albedo of the two bodies, as well as in the inclination of orbit to line of sight. The stars *β Lyræ* and *RR Centauri* are good examples of the type. E. E. M.

Stellar Spectroscopy in 1903.

Nebulæ.—Mr. Perrine (Lick Obs. *Bulletin*, No. 31) has made bold attempts to photograph the spectrum of the nebulosity round Nova *Persei*, and with an exposure of thirty-four hours has succeeded in getting traces enough to convince him that the spectrum is not that of a gaseous nebula, but resembles more closely the spectrum of the Nova in its earlier stages.

New Stars.—The spectrum of Turner's Nova *Geminorum* leaves no doubt as to the nature of the star. The following

notes relating to it have been published, of which the last three contain photographic illustrations :

Professor Pickering, H.C.O. *Circular*, No. 70, and *Astroph. Jour.* xvii. 305.
Professor Hale, *Astroph. Jour.* xvii. 303.
Mr. Perrine, Lick Obs. *Bull.* No. 37, *Astroph. Jour.* xviii. 297.
Messrs. Reese and Curtis, Lick Obs. *Bull.* No. 37, *Astroph. Jour.* xviii. 299.

On the theory of new stars Professor H. Ebert contributes an article to *Ast. Nach.* **164**, 66.

Classification of Stellar Spectra.—In the *Publications* of the Yerkes Observatory (vol. iii. pt. v.) Professor Hale and Messrs. Ellerman and Parkhurst give a full account of their studies of the spectra of stars of Secchi's Fourth Type ; and it forms a remarkable record of a research admirably planned, and forced through to a successful issue in spite of the great difficulties with which it is beset. One hundred and fifty (150) photographs of spectra of twenty-five stars were taken, and in order to study an extended range (3930–6600 λ) the spectra were photographed in four sections with appropriately sensitised plates. Many of the stars studied are so faint that exposures of five or six hours were not uncommonly necessary, and in one case a photograph received twenty-four and a half hours' exposure (on three nights). Forty-three (43) photographs of eight stars were chosen for special detailed measurement, the others being used for comparative study. In all there were 537 lines dealt with, and for each line a wave-length is deduced, corrected for the Earth's orbital and the star's radial velocity. As a result of various processes of exclusion it comes about that forty-nine of the measured lines are common to all of the eight stars, and these give an idea of the precision of the measures and a final check upon the adopted values of motion in the line of sight.

The research shows that the spectrum of Type IV. contains, as McClean's photographs showed, very numerous lines in addition to the characteristic flutings ; and these flutings are identified as dark reversals of the bright flutings of cyanogen and of Swan's candle-spectrum. Plate 7—to mention one of an admirable series of photographic illustrations—sums up this part of the research in a striking way ; it is based on a careful discussion of the measured wave-lengths corresponding to the edges of the flutings. About 200 of the lines studied are regarded as bright lines, though none of them can be identified with certainty at present ; whilst among the dark lines there are so many conspicuous lines corresponding in position with those observed as widened lines in Sun-spot spectra, that the writers base on the correspondence a suggestion that the general radiation of these stars may approximate more nearly to that of the spotted

region of the Sun's surface than to that of the unspotted part. The relation of the fourth-type spectrum with that of the Wolf-Rayet stars is considered in detail ; and in considering classification and evolution the writers take the view that the stars with spectra of Secchi's third and fourth types are coordinate branches in development from the Sun, thus agreeing with Vogel's classification, and disagreeing with Lockyer's contention that stars of these types are far removed from each other in point of development.

Radial Velocity of Stars.—In the course of the year two publications have appeared relating to the results obtained in the scheme of cooperation of certain observatories in determining the radial velocity of chosen "Standard Velocity Stars." Mr. Newall (*Monthly Notices*, lxiii. 296) gives the results obtained for three stars in 1902 at the Cambridge Observatory. Messrs. Frost and Adams (*Astroph. Jour.* xviii. 237) give results relating to thirteen stars observed 1902–3.

The following table summarises these results :

	Epoch.	Yerkes Obs.	Epoch.	Cambridge Obs.
α Arietis	1902·84	−13·7 km/sec.	1902·8	−14·3 km/sec.
α Persei	2·77	− 2·1	1902·8	− 2·6
β Leporis	2·85	−12·4		
β Geminorum	3·12	+ 3·4		
α Crateris	3·23	+47·4		
α Boötis	3·12	− 4·8	1902·4	− 5·8
β Ophiuchi	3·14	−11·1		
γ Aquilæ	2·98	− 1·8		
ε Pegasi	2·65	+ 6·2		
γ Piscium	2·73	−10·9		
ι Aurigæ	2·85	+19·0		
ε Leonis	3·20	+ 5·5		
γ Cephei	3·13	−41·2		

Studies of Special Stars.—

Sir Norman Lockyer and Mr. Baxandall on γ *Cygni*, *Phil. Trans.* A. **201**, 205.

Mr. Stebbins on *o Ceti*, *Astroph. Jour.* xviii. 341.

Mr. Reese on ϕ_2 *Orionis*, *Astroph. Jour.* xvii. 310.

Mr. Adams on $61_{1 \text{ and } 2}$ *Cygni*, *Astroph. Jour.* xviii. 67.

Mr. Frost on { *ξ Persei*, *c Persei* ; 25 *Orionis*, *β Piscium* } *Astroph. Jour.* xviii. 388.

Orbits and Parallax of Spectroscopic Binaries.—Professor Nijland points out (*Ast. Nach.* **161**, 103) a small simplification in Dr. Schwarzschild's method (*Ast. Nach.* **152**, 68) of computing the orbit of a spectroscopic binary.

Mr. W. S. Adams has computed (*Astroph. Jour.* xvii. 68) an

orbit for the spectroscopic binary η *Orionis* (the brighter component of the fourth magnitude of the well-known visual pair).

Mr. W. J. Hussey has calculated (Lick Obs. *Bulletin*, No. 32, and *Astroph. Jour.* xvii. 378) the parallax of the binary δ *Equulei* (period 5·7 years) from spectroscopic observations.

Variable Radial Velocity.—The following stars have in the course of the year been found to exhibit signs of variable velocity in the line of sight :

	R.A. h m	Decl. ° ′	Mag. m		
π Andromedæ	0 32	+33 10	4·4	Yerkes	Frost and Adams, *Astroph. Jour.* xviii. 384
ξ Cassiopeiæ	0 37	+49 58	4·8	,,	,, ,,
ν Andromedæ	0 44	+40 32	...	Lick	Reese, Lick Obs. *Bull.* 31 and *Astroph. Jour.* xvii. 308
β Arietis	1 49	+20 16	...	Potsdam	Vogel, *Ast. Nach.* **163**, 145
π_4 Orionis	4 46	+ 5 26	4·0	Lick	Reese, Lick Obs. *Bull.* 31 and *Astroph. Jour.* xvii. 309; Frost and Adams, *ib.* xvii. 153
δ Ceti	4 31	− 0 6	4·1	Yerkes	Frost and Adams, *Astroph. Jour.* xvii. 150
ν Eridani	4 31	− 3 33	4·1	,,	,, ,,
τ Tauri	4 36	+22 46	4·4	,,	Frost and Adams, *Astroph. Jour.* xvii. 246
π_5 Orionis	4 49	+ 2 17	3·9	,,	Frost and Adams, *Astroph. Jour.* xviii. 150
o Orionis	5 17	− 0 29	4·6	,,	Frost and Adams, *Astroph. Jour.* xviii. 385
ψ Orionis	5 22	+ 3 1	4·7	,,	Frost and Adams, *Astroph. Jour.* xvii. 246
χ Aurigæ	5 25	+32 8	5·0	,,	Frost and Adams, *Astroph. Jour.* xviii. 385
ι Orionis	5 30	− 5 59	3·0	,,	Frost and Adams, *Astroph. Jour.* xviii. 386
ζ Tauri	5 32	+21 5	3·0	,,	Frost and Adams, *Astroph. Jour.* xvii. 150
ν Orionis	6 2	+14 47	4·4	,,	Frost and Adams, *Astroph. Jour.* xviii. 386

	R.A. h m	Decl. ° ′	Mag. m		
σ Geminorum	7 37	29 7	...	Lick	Reese, Lick Obs. *Bull.* 31 and *Astroph. Jour.* xvii. 309
ι Argus	8 3	−24 1	...	„	Campbell, Lick Obs. *Bull.* 31 and *Astroph. Jour.* xvii. 309
ω Ursæ Majoris	10 48	+43 47	...	Potsdam	Vogel, *Ast. Nach.* **163**, 145
γ Corvi	12 11	−16 59	...	Lick	Campbell and Curtis, *Astroph. Jour.* xviii. 307
η Virginis	12 15	0 7	4·1	Yerkes	Frost and Adams, *Astroph. Jour.* xvii. 152; Campbell and Curtis, *ib.* xviii. 307
ε Ursæ Majoris	12 49	+56 33	...	„	Adams, *Astroph. Jour.* xviii. 68; Vogel, *Ast. Nach.* **163**, 146
α Draconis	14 2	+64 51	...	Lick	Campbell and Curtis, *Astroph. Jour.* xviii. 307
α Coronæ Bor.	15 30	+27 3	...	Potsdam	Hartmann, *Ast. Nach.* **163**, 31
β Scorpii	16 0	−19 32	...	Yerkes	Adams, *Astroph. Jour.* xviii. 69; Slipher. Lowell Obs. *Bull.* No. 1
ε Herculis	16 56	+31 5	...	„	Adams, *Astroph. Jour.* xviii. 69
u Herculis	17 14	+33 12	4·9	„	Frost and Adams, *Astroph. Jour.* xvii. 381
λ Scorpii	17 27	−37 2	...	Lowell	Slipher. Lowell Obs. *Bull.* No. 4
18 Aquilæ	19 2	+10 50	5·1	Yerkes	Frost and Adams, *Astroph. Jour.* xviii. 387
δ Aquilæ	19 21	+ 2 55	...	Lick	Campbell and Curtis, *Astroph. Jour.* xviii. 308
57 Cygni	20 50	+44 0	4·6	Yerkes	Frost and Adams, *Astroph. Jour.* xvii. 381
2 Lacertæ	22 17	+46 2	4·8	„	Frost and Adams, *Astroph. Jour.* xviii. 387
6 Lacertæ	22 26	42 37	4·6	„	„ „
1 Hev. Cassiopeiæ	23 25	+58 0	...	„	Frost and Adams, *Astroph. Jour.* xviii. 388

M. Tickhoff (*Ast. Nach.* **164**, 49) gives an account of observations of β *Aurigæ*.

Herr Ludendorff (*Ast. Nach.* **164**, 81) discusses observations of the brightness of ϵ *Aurigæ*, and arrives at the conclusion that it is an *Algol* variable of period 27 years.

Rowland's System of Wave-Lengths.—In the past year or two several important discussions of systems of wave-lengths have appeared. We may call attention to the following :

Messrs. Perot and Fabry.	*Compt. R.* **130**, 653 ; *Astroph. Jour.* xv. 270 and xvi. 36.
M. Hamy	*Compt. R.* **130**, 700.
Prof. Louis Bell... ...	*Astroph. Jour.* xv. 157 and xviii. 191.
Dr. Eberhard	*Astroph. Jour.* xvii. 141.
Dr. J. Hartmann ...	*Astroph. Jour.* xviii. 167, trans. from the October No. of *Zeitschrift f. wissensch. Photographie, Photophysik und Photochemie,*

H. F. N.

Boss's Standard Catalogue.

During the year Professor Lewis Boss has published in the *Astronomical Journal* a series of most important and interesting papers in connection with a standard catalogue of 627 stars distributed over both hemispheres. Such a catalogue is, as he justly remarks, of fundamental importance in the determination of the solar apex, and in all questions relating to the movements of the sidereal system. For the proper motion of a single star the systematic corrections applied to the past observations may be of little consequence, but when the proper motions of a large number of stars are computed these corrections acquire a high importance. For instance, the position of the solar apex is 10° further north if the systematic corrections to the various catalogues employed in the computation of proper motions are such as make them conform to Professor Boss's system rather than that of the *Berliner Jahrbuch*.

The earliest observations used in Professor Boss's catalogue are those made at Königsberg in 1820. The catalogues of Bradley, Mayer, Groombridge, Piazzi are not, in Professor Boss's opinion, valuable in the formation of a standard system, though they may be very useful for the determination of the proper motions of other stars when such a system is formed. In this respect the catalogue differs to some extent from those of Auwers and Newcomb.

Comparisons with the catalogues of Auwers and Newcomb

(*A. J.* 531–532) show a small periodic term in the right ascensions for 1900·0 and the proper motions of the equatorial stars, but much more marked differences when the stars are arranged in zones of declination. Roughly speaking the systems of Auwers and Newcomb agree in right ascension, with the exception of a constant equinox correction. Professor Boss remarks that he has carefully considered these differences, and, though there is some uncertainty with the southern stars, is satisfied that existing testimony is in favour of his own system. For the position and motion of the equinox Newcomb's values have been used. The uncertainty attaching to this can only be corrected by further observations, and "it is earnestly to be hoped that these will soon be offered not from Greenwich only, but also from many other observatories situated in latitudes more favourable for the purpose."

There are small terms of the form $a \sin \alpha + b \cos \alpha$ in the differences of declinations of the systems Boss-Newcomb and Boss-Auwers, but, as with the right ascensions, the greatest differences are seen when the stars are arranged in zones of declination. There are also considerable differences in the proper motions, particularly of the southern stars, between this catalogue and "Boss's declinations of 1875." The most important features of this comparison are the large discordances between the proper motions in Boss's and Auwers's system of the stars north and south of 45° N. Dec.—the discordance which produces a difference of 10° in the determination of the direction of the Sun's motion. Newcomb's system agrees more nearly with Boss's in this particular.

The catalogue is given in *A. J.* 531–532, the methods of forming it in *A. J.* 534 and *A. J.* 540–541. The systematic errors of right ascension of the form $a \sin \alpha + b \cos \alpha$, the discussion and elimination of which is due to Newcomb, do not offer much difficulty; incidentally Professor Boss remarks that in some modern observations sufficient care is not taken to eliminate this form of error, a matter which should be easy with our modern clocks, as Bessel and Struve were able to avoid it with ordinary clocks exposed to considerable variations of temperature. The most obvious causes of error of right ascension depending on the declinations are (i.) the collimation, (ii.) the pivots, (iii.) the polar deviation n. Other causes are illumination of the wires and any want of fixity in the object-glass. To determine the errors arising from these causes in various catalogues *Polaris* and 45 stars extending to −20° Dec. which had been systematically well observed were taken in the first instance, and standard right ascensions and proper motions formed for these stars. The residuals of these stars in the different catalogues, grouped in zones 10° wide, gave a preliminary system of corrections, and the right ascensions of 113 additional stars were found. The zone corrections were redetermined and the catalogue

further expanded. Special treatment was necessary for the stars south of $-20°$ and for the close polars north and south.

The declinations are similarly treated, using Boss's previous catalogues as a provisional system. The corrections depending on right ascension are first disposed of, and those depending on declination caused by flexures, division error, error of assumed latitude, error of adopted constant of refraction. The greatest difficulty experienced in this part of the work was in correcting McClear's Cape Catalogue of 1833. The importance of this catalogue arises from its being the earliest southern catalogue suitable for the formation of a standard system previous to 1830.

No. 536 of the *Astronomical Journal* is devoted to the consideration of the magnitude equation of the Standard Catalogue. Comparisons were made with a large number of catalogues, and the important result obtained that there is no appreciable difference between the average magnitude equations for chronographic and eye and ear observing, at any rate between the first and sixth magnitude. From the determinations made at various observatories the magnitude equation $-0^{s}\cdot0077\ (M-3\cdot5)$ is derived as applicable to the Standard Catalogue. Professor Boss remarks: "The determination of absolute magnitude equation should be regarded as an indispensable requisite in all observations aiming at precision." He recommends the use of screens.

In *A. J.* 545 he compares the declinations of Auwers' Bradley with those of the Standard Catalogue. Proceeding on the assumption that the differences between the quadrant pointing north and south are due to a change in eccentricity, and can be represented by a formula $k+x\sin\zeta$, he finds that $k=0''\cdot42$ and $x=1''\cdot20$. He discards the corrections given by Auwers as applicable to the zenith distances, and finds corrections which make the declinations agree with his own standard, subject to the above relationship between the corrections to be applied to equal zenith distances north and south. He shows that the observation of stars at upper and lower culmination are in fair agreement with his formula. He tabulates the corrections to be applied to Auwers' Bradley, and proposes to apply them to extend his catalogue to include a large number of secondary standard stars.

In *A. J.* 549-550 are given the systematic corrections to reduce a large number of the more important catalogues to this system, and the weights to which they are entitled. The object of first importance as regards these corrections is to obtain positions and motions of stars, in large numbers, which shall be as far as possible free from systematic error. Professor Boss's work is a step of fundamental importance in the progress of our knowledge of the sidereal universe, and it is with the greatest satisfaction we note that Professor Boss is continuing his researches. F. W. D.

Dr. Auwers' Re-reduction of Bradley's Observations.

Dr. Auwers commenced his great work of the re-reduction of Bradley's Observations in 1866, and completed it in 1876. The work was planned to consist of three volumes, the first containing the basis of the reduction, the second the mean right ascensions and declinations of the single observations for 1755·0, the third the catalogue and the proper motions of the stars. Vol. ii. was published in 1882, vol. iii. in 1888, and vol. i. in August 1903.

The volume contains a complete account of the method of reduction of the star-catalogue, and also of Bradley's Sun and planet observations, and a discussion of the observations of stars made with the zenith-sector at Wanstead and Greenwich.

The first section is devoted to the transits, the method employed for forming the standard right ascensions of the stars to be subsequently used for clock error being of special interest. Eleven stars were taken, *α Lyræ*, *γ*, *α*, *β Aquilæ*, and *α Cygni* forming one group, and *Rigel*, *Capella*, *α Orionis*, *Castor*, *Procyon*, *Pollux* forming another. The position of the stars of the first group relatively to *α Aquilæ* and of the second relatively to *Procyon* were first determined. The difference of right ascension of *α Aquilæ* and *Procyon* was then determined, using all the available comparisons between the stars of one group and the means of consecutive culminations of stars of the second group. Means were formed for each month, and a final mean difference obtained freed from errors which arose from diurnal variations of clock rate, &c. The right ascensions of the rest of Maskelyne's 36 fundamental stars were next determined. The very skilful determination of the right ascensions of the clock stars is the main cause of the freedom from periodic error in Auwers' Catalogue, a freedom which Bessel's *Fundamenta* did not possess.

The second section explains the method of reduction of the declinations. The determination of the zenith-point corrections is fully described. These depend on the sector observations made by Bradley and Maskelyne at Greenwich and by Bradley at Wanstead. The determination was made directly for some days, but on other days none of the sector stars were observed at the quadrant. Consequently it was necessary to connect other stars, particularly the 36 Maskelyne stars and 7 stars in *Gemini*, which Bradley frequently observed, with the sector stars on days when both were observed at the quadrant, and use the positions of the Maskelyne stars thus determined for days when no sector stars were observed.

The reduction of the sector observations is given in Section III., and this is—apart from its relation to the quadrant observations—a very important and considerable work. Bradley's observations

at Greenwich from 1749 to 1760 gave the zenith distances of 85 stars with 1427 observations. In the Wanstead series from 1727 to 1729 there are 1830 observations of 70 stars, distributed over a zone $12\frac{1}{2}^\circ$ wide passing through the zenith, and 32 of these stars are additional to the Greenwich series. Three series of Maskelyne's sector observations, 1768–1769, 1776–1777, 1785–1786, giving the zenith distances of 36, 28, and 28 stars respectively, are next considered. The whole of the sector observations are compared and unified, and as a final result a catalogue of the declinations of 130 stars for 1755·0 is formed. Of these stars 114 occur in the quadrant observations; and the positions of these 114 stars are used to give a homogeneous and accurate series of zenith-point corrections.

Section IV. contains the observations of the Sun. Attention may be drawn to the personalities of the observers, which are fully discussed. The observations of the Sun give an equinox correction of $+^s\cdot056$, but the probable error is at least $\pm0^s\cdot10$, and on this account Dr. Auwers did not use the proper motions he derived from Bradley's observations for a new determination of the precession.

The next sections V. and VI. contain Dr. Auwers' researches on the correction to be applied to the quadrant observations for division error. He assumed that the cause of the discrepancies was a bending of the quadrant—the centre of the cross-wires of the telescope being on the normal to the quadrant would be raised or lowered by an amount depending on the angle the quadrant at that point made with the vertical plane. A number of transits made with the quadrant are utilised to determine its departure from a plane at each point, and the correction required by the zenith-distances is readily deduced. The circumpolar observations are also employed for the quadrant north, and the Sun observations for zenith distances 29°–73° quadrant south. The determination of these division-corrections is a matter of great difficulty, and Dr. Auwers' treatment has received some criticism.

Section VII. contains the re-reduction of Bradley's planetary observations.

The publication of this volume may fittingly recall the words of Dr. Glaisher in presenting the Gold Medal of the Society to Dr. Auwers in 1888. "Dr. Huggins, in transmitting this medal to Dr. Auwers, and conveying to him our congratulations upon the completion of so great a work, may I ask you at the same time to express to him not only our admiration of the manner in which the most refined skill has been combined with the most patient care in its performance, but also our personal acknowledgments for the years of laborious industry in which, with untiring zeal, he has devoted his time and powers to the not unworthy task of applying to the advance of modern astronomy the concluding labours of Bradley's useful life?"

F. W. D.

The Astrographic Catalogue and Chart.

During the past year two* of the observatories taking part in making the Astrographic Catalogue have begun publication—viz. the observatories of the Vatican at Rome and of Helsingfors, and besides these the Potsdam Observatory has published a third volume. Remembering that Paris has already issued its first volume, that Greenwich is on the eve of publication, and that the computation of the Oxford zone is practically done, the present state of the work may be summarised by saying that the Catalogue from the North Pole to declination 18° N. is beginning to be published; that from 18° N. to 16° S. the work of measurement and reduction is well advanced; the next section, which was originally allotted to certain South American observatories, is scarcely begun; and that the plates of the remaining part of the sky—*i.e.* from 40° S. to the South Pole, are being rapidly measured by the observatories at the Cape and Melbourne.

In these examples of publication from the four observatories mentioned, in each case a plate is taken as a unit, and all the stars on the plates are measured, even though they fall beyond the lines where the plate intersects its neighbours in the same zone or of declination two degrees above or below, so that measures of the same star may occur three, four, or even five times in the Catalogue on different plates. A measure is distinguished by the number of a plate and its number on that plate, and a star may therefore have several designations; which does not seem to be a convenient arrangement, unless, as is the case in the Helsingfors and Potsdam volumes, the right ascension and declination (approximate only in the latter case) of the star is attached to each measure. The resolutions of the conferences which have determined the plan of the astrographic work require only that the original measures of the rectilinear coordinates should be printed, with sufficient data to convert these into equatorial coordinates of the epoch 1900·0, but the various observatories have interpreted these resolutions more or less generously. Its terms have been carried out exactly by the Paris and Vatican Observatories. In these two cases the rectilinear coordinates are given measured in millimetres, and it may be noted that the fourth decimal place is given with the central lines of the réseau as axes, and with origin at the centre of the plate. With each plate is given the plate constants, by help of which these measured coordinates can be transformed to others, referred to axes coinciding with and perpendicular to a celestial meridian, and having for origin the point in the sky adopted as the theoretical centre of the plate. The volumes of the Potsdam

* Since this note has been in type four fascicules of the Catalogue have been issued by the Algiers Observatory, to which the zone between declination −1° and +4° is allotted.

Catalogue hitherto published do not give the plate constants. The Helsingfors Catalogue not only gives the constants but corrections for divisions and scale errors also in much detail, applies them to find the "standard" coordinates above described, and then deduces from these the ordinary equatorial coordinates, right ascension and declination.

Professor Donner, the director of Helsingfors Observatory, considers the present publication as merely subsidiary. He proposes to make a final catalogue in which all these star-places will be collected, thus going a long way beyond the present scheme laid down at the conferences, but if all the cooperating institutions could command sufficient resources to follow his lead, the result would be worthy of the great work.

In other respects the four catalogues show differences in detail, and in none more so than in the arrangement of the plates in the books. In the Potsdam volumes the plates are arranged in groups of the same declination, and the plates of each group are arranged in order of R.A. ; but a group covers only a few hours of right ascension, and hiatus is frequent. The stars on each plate are printed in order of right ascension, which, as has been said, is approximately given in the same line. The Paris volume already issued contains the plates whose centres are at declination 24°, and cover the whole of that zone, the stars being arranged on the plates nearly in order of the x coordinate increasing. The book from the Vatican contains fifty-four plates, whose centres are either at declinations 60°, 61° or 62° N., arranged in a somewhat arbitrary manner, the stars being printed in order of increasing x coordinate. The Helsingfors volume is numbered IV., and contains all the plates from R.A. 9^h to 12^h in the zone allotted to that Observatory (centres from Dec. 40° to 46°), and these are numbered and arranged as here illustrated. No. 1 has R.A. $0^h\,0^m$, Dec. 40°. Nos. 2, 3 and 4 are in R.A. $0^h\,0^m$, Dec. +42°, 44°, 46° respectively. No. 5 has R.A. $0^h\,5^m$, Dec. +41°, and so on. These varieties of arrangement make it clear that if the Astrographic Catalogue is to be regarded as a homogeneous work, a final catalogue as proposed by Professor Donner is inevitable.

Of other differences in details of the four catalogues, a notable example is furnished by the references to other star catalogues. Potsdam gives the zone and number in the Bonn *Durchmusterung* of such stars as appear in that work. Rome and Paris the numbers in the *Astronomische Gesellschaft* of stars used for determining the plate constants. In the Helsingfors list the places of the stars in the *Gesellschaft* catalogues, brought up to epoch 1900·0, are added for comparison with the photographic places, but not the catalogue numbers. All the catalogues give a determination of the magnitude of each star.

The above may be sufficient description of the results at present derived from the astrographic plates. The casual inquirer may possibly find some difficulty in making ready use

of the catalogues in their present form. Failing reduction of at least some of the measures to equatorial coordinates, the insertion of reference numbers to stars in other catalogues is an advantage. The accuracy of the star places does not quite reach the standard originally expected, but does not fall far short of it. Father Rodriguez de Prada gives for the probable error of a determination of right ascension, derived from the mean of four plates taken at Rome, $\pm^{s}\cdot048$, the equivalent of $\pm0''\cdot35$, and in declination also $\pm0''\cdot35$. M. Lœwy gives the probable error of a right ascension or declination deduced from one plate $\pm0''\cdot31$. No evaluation of the probable error is given of the Helsingfors work, but a casual examination of this seems to show that the P.E. in this case will be somewhat smaller than these.

The distribution of the enlargements on paper of chart plates by the French observatories has been continued during the year.

H. P. H.

Geodesy and Universal Time.

In the report to the Board of Visitors for 1903 the Astronomer Royal gave $9^{m}\ 20^{s}\cdot974\pm\cdot0113$ as the result for the difference of longitude between the meridians of Paris and Greenwich as determined in the spring of 1902, and $9^{m}\ 20^{s}\cdot909\pm\cdot0047$ as the result from the determination in autumn of the same year. The definitive value has not yet been derived from these figures, but the matter waits for comparison with the results found by the French observers.

In the summer of 1903 the difference of longitude between Greenwich and the Prussian Geodetic Institute at Potsdam was determined by Professor Albrecht and Herr Wanach, using Repsold registering micrometers on a transit of the coudé form. The result of this work is not yet published, but it is known that using previously determined values of the arc, Potsdam–Paris, it is not inconsistent with the figures in the previous paragraph.

The longitude of the Great Trigonometrical Survey of India has been known for many years to be in error by $2'\ 30''$. A recent publication* of the survey states that the longitudes of the maps are now referable to the Greenwich meridian, taking the longitude of the Madras Observatory as $80°\ 14'\ 54''$. This value is based on the determination of the longitude of Madras by Major Burrard and Major Lenox-Conyngham in 1895, which gave $80°\ 14'\ 47''$; the difference of $7''$ being accounted for by the following reasons. Kalianpur is the origin of the survey, and this place was found to be $2°\ 35'\ 29''\cdot5$ west of Madras when the arc Madras–Kalianpur was measured by astronomical methods, but the geodetic measures gave $2°\ 35'\ 36''\cdot6$ as the value. The

* Survey of India, *Professional Papers*, No. 7, 1903.

astronomical value is now used for forming the longitude of Kalianpur, but the longitude of Madras on the maps is given as the most recent *geodetic* value.

It is proposed to make determinations of gravity in the Himalayas and other parts of India by half-second pendulums of the Sterneck pattern. The officers above-named made series of observations at Greenwich and Kew in 1903 for the purpose of standardising a set of these instruments.

From the beginning of the year 1903 the time-ball at Shanghai has been dropped each day exactly eight hours earlier than Greenwich mean noon, to bring the time of the port in harmony with the universal time system. East European time, which is the time of the meridian two hours east of Greenwich, has been adopted for all the British Colonies in South Africa. A Bill has been laid before the Parliament of Portugal with the object of making Greenwich time the standard in that country.

H. P. H.

Papers Read before the Society from March 1903 to January 1904.

1903.

Mar. 13. On a new and accurate method of determining time, latitude and azimuth with a theodolite. W. E. Cooke.

On the desirableness of a re-investigation of the problems growing out of the mean motion of the Moon. Simon Newcomb.

On three of Sir William Herschel's observed nebulous regions in *Orion*. Max Wolf.

Proposal for the establishment of a southern belt of latitude stations. S. C. Chandler.

On the period and light curve of 7514 *UY Cygni*. A. Stanley Williams.

On the nebula *h* 2302 (N.G.C. 7822) *Cassiopeiæ*; the region surrounding ♅ II. 457 (N.G.C. 1665) *Eridani*; with ten new nebulæ; and on ♅ III. 558 (N.G.C. 7492) *Aquarii*. Isaac Roberts.

Observations of Comet *b* 1902 (Perrine) from photographs taken at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Note on photographs of Comet *d* 1902 (Giacobini) obtained with the 30-inch reflector at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Note on photographs of Comet *a* 1903 (Giacobini) obtained with the 30-inch reflector at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Velocity in the line of sight. Selected Stars. Cambridge Observatory, I. 1902. H. F. Newall.

Apr. 8. Rotation period of the markings on *Jupiter*. W. F. Denning.

A standard scale for telescopic observation. Percival Lowell.

On the orbit of Σ 2525. W. Bowyer.

Note on a new star in the constellation of *Gemini*. F. A. Bellamy.

Transits observed with the Durham Almucantar between 1901 November 23 and 1902 December 15. R. A. Sampson.

1903.

Apr. 8. On the place of Nova *Geminorum*. Max Wolf.

May 8. A possible cause of the Moon's obscurity on April 11. Rev. S. J. Johnson.

Results of micrometric measures of double stars made with the 28-inch refractor at the Royal Observatory, Greenwich, in the year 1902. Communicated by the Astronomer Royal.

Observation of the partial eclipse of the Moon, 1903 April 11. E. M. Antoniadi.

Expressions correctes de l'heure et des coordonnées des étoiles dans le système de l'axe instantané. F. Folie.

Eclipse of the Moon of 1903 April 11, observed at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Mean daily area of Sun-spots for each degree of solar latitude for each year from 1874 to 1902, as measured on photographs taken at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Areas of faculæ and Sun-spots compared with diurnal ranges of magnetic declination, horizontal force and vertical force, as observed at the Royal Observatory, Greenwich, in the years 1873 to 1902. Communicated by the Astronomer Royal.

Observations of stars occulted by the Moon during the Eclipse of 1903 April 11, made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

June 12. Note on the double star 31 *Leonis*. S. W. Burnham.

The companion to Σ 1594. S. W. Burnham.

On the verification of the Newtonian Law. E. W. Brown.

Note on the use of Peirce's criterion for the rejection of doubtful observations. S. A. Saunder.

On a probable relationship between the solar prominences and corona. W. J. S. Lockyer.

Note on the present condition of the lunar theory. E. Nevill.

On the relation existing between the light changes and the orbital elements of a close binary system, with special reference to the figure and density of the variable star *RR Centauri*. A. W. Roberts.

Recent observations of *Mars* and *Jupiter*. W. F. Denning.

The spectra of Sun-spots in the region B—D. Rev. A. L. Cortie.

Experiments as to the actuality of the "canals" observed on *Mars*. J. E. Evans and E. W. Maunder.

1903.

June 12. The great nebula in *Auriga*. Max Wolf.

Observations of the satellite of *Neptune* from photographs taken at the Royal Observatory, Greenwich, between 1902 November 12 and 1903 April 27. Communicated by the Astronomer Royal.

Examination of Mr. Whittaker's "Undulatory explanation of Gravity," from a physical standpoint. G. Johnstone Stoney.

Mean areas and heliographic latitudes of Sun-spots in the year 1902, deduced from photographs taken at the Royal Observatory, Greenwich, at Dehra Dûn (India), and in Mauritius. Communicated by the Astronomer Royal.

Observations of the new star in *Gemini* made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Further observations of the new star in *Perseus*, made at the Radcliffe Observatory, Oxford. Communicated by the Radcliffe Observer.

Further observations of the new star in *Auriga*, made at the Radcliffe Observatory, Oxford; with the mean magnitudes for the years 1902–1903. Communicated by the Radcliffe Observer.

On oscillating satellites. H. C. Plummer.

The National Argentine Observatory. J. M. Thome.

Positions of 166 stars around Nova *Geminorum*, with a discussion of the systematic differences between two exposures on the same plate. F. A. Bellamy.

On the possible identity of Nova *Geminorum* with a small star photographed before the outburst. H. H. Turner.

On the position of *X Geminorum*. F. A. Bellamy.

Nov. 13. On the construction of telescopes whose relative or absolute focal length shall be invariable at all temperatures. F. L. O. Wadsworth.

A derivation of Hill's equation by a direct substitution. R. A. Herman.

Ephemeris for physical observations of the Moon, 1904. A. C. D. Crommelin.

Results of double-star measures made with the 8-inch equatorial at Windsor, New South Wales, in 1902. John Tebbutt.

Observations of variable stars made under the direction of the late Sir C. E. Peek, Bart. Edited and discussed by H. H. Turner.

On the systematic proper motions of bright stars relatively to faint stars in the Oxford zones ($+25°$ to $+31°$). H. H. Turner.

Observations of *Mars* in 1903. Rev. T. E. R. Phillips.

1903.

Nov. 13. Measures of southern double stars made at Shanghaï, 1902–1903. J. L. Scott.

Observations of Borrelly's Comet (*c* 1903) made at the Natal Observatory, Durban. Communicated by E. Nevill.

Remarks on a paper by Mr. W. E. Cooke on a new method of determining time, latitude and azimuth. E. B. H. Wade.

Preliminary note on the effect of the direction of gravity on lunar observations. E. B. H. Wade.

Observations of white spots on *Saturn* in 1903. A. Stanley Williams.

A spectrographic study of *β Lyræ*, Rev. W. Sidgreaves.

On the use of the stereo-comparator for plates on which a réseau has been impressed. Max Wolf (with introductory note by H. H. Turner).

Preliminary note on a method of photographing the Moon with surrounding stars. H. H. Turner.

Errors in the Moon's tabular longitude as affecting the comparison of the Greenwich meridian observations from 1750 with theory. P. H. Cowell.

On the large Sun-spots of 1903 October 4–18, and October 25–November 6, and the associated magnetic disturbances. Communicated by the Astronomer Royal.

Note on photographs of Comet *c* 1903 (Borrelly) taken with the 30-inch reflector at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

Short method for the calculation of the orbits of celestial bodies. D. A. Pio.

Dec. 11. The rotation period of the planet *Saturn*. G. W. Hough.

The shower of *Leonids* in 1903. W. F. Denning.

On graphical methods of determining the local or Greenwich time of sunset at different places within a given region. H. H. Turner.

Observations of the *Leonid* meteors of 1903, made at the Royal Observatory, Greenwich. Communicated by the Astronomer Royal.

On oscillating satellites (second paper). H. C. Plummer.

An examination of the relative star-density in different parts of the plates forming the Harvard photographic sky-map. J. C. W. Herschel.

On the semi-diameter, parallactic inequality, and variation of the Moon from Greenwich meridian observations, 1847·0 to 1901–5. P. H. Cowell.

1903.
Dec. 11. Ephemeris for physical observations of *Saturn*, 1903–1904. A. C. D. Crommelin.

Two drawings of the Mare Serenitatis by John Russell, R.A., affording some hitherto unpublished evidence as to the appearance of Linné in the year 1788. A. A. Rambaut.

1904.
Jan. 8. Cape double-star results, 1903. R. T. A. Innes. Communicated by H.M. Astronomer.

Transformation of Hansen's Tables. P. H. Cowell.

Note on the use of long-focus mirrors for eclipse work. H. H. Turner.

New double stars detected with the $17\frac{1}{4}$-inch reflector during the year 1903. Rev. T. E. Espin.

Ephemeris for physical observations of *Jupiter*, 1904–1905. A. C. D. Crommelin.

The rotation period of *Saturn* in 1903. W. F. Denning.

The "great" magnetic storms, 1875 to 1903, and their association with Sun-spots, as recorded at the Royal Observatory, Greenwich. E. W. Maunder. Communicated by the Astronomer Royal.

The aurora and magnetic disturbance. William Ellis.

Suggested connection between Sun-spot activity and the secular change in magnetic declination. Mrs. E. W. Maunder.

On the chromatic correction of object-glasses. A. E. Conrady.

An account of tables to facilitate the working of combined altitudes by Saint-Hilaire's method. Lieut. Simpson-Baikie.

Further note on the "great" magnetic storms, 1875–1903, and their association with Sun-spots. E. W. Maunder.

Note on Mr. Ritchey's photographs of the nebula in *Andromeda*. W. H. Wesley.

List of Public Institutions and of Persons who have contributed to the Library, &c., since the last Anniversary.

His Majesty's Government in India.
The Lords Commissioners of the Admiralty.
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British Horological Institute.
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Geological Society of London.
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Bombay Branch of the Royal Asiatic Society.
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Bordeaux, Society of Physical and Natural Sciences.
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Brisbane, Royal Geographical Society of Australasia.
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Brussels, Royal Academy of Sciences of Belgium.
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Calcutta, Asiatic Society of Bengal.
Canada, Department of Interior.
Canada, Department of Marine.
Canada, Geological Survey.
Canada, Royal Society.
Cape of Good Hope, Geodetic Survey of South Africa.
Cape of Good Hope, Royal Observatory.
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Christiania, Society of Sciences.
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Paris, Philomathic Society.
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Potsdam, Central International Geodetic Bureau.
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San Francisco, Astronomical Society of the Pacific.
Stockholm Observatory.
Stockholm, Royal Swedish Academy of Sciences.
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ADDRESS

Delivered by the President, Professor H. H. Turner, on presenting the Gold Medal of the Society to Professor G. E. Hale.

The Council have awarded the Gold Medal to Professor George E. Hale "for his method of photographing the solar surface and other astronomical work," and it is now my pleasant duty to lay before you the grounds on which this award has been made.

"It cannot be too often repeated," remarks Professor Hale himself in a recent memoir, "that the Sun is the only star whose phenomena can be studied in detail." We all assent at once not only to the proposition itself, but to the obvious corollary that particular attention should be paid to solar phenomena; and yet it would appear from the history of astronomy that the statement, however often repeated, has fallen on deaf ears. If we turn, for instance, to the list of awards of our medal, which, unless the Society has been prejudiced, should reflect in some degree the relative interest taken in the various departments of astronomy, we find a score of recognitions for good work in lunar or planetary theory; another score for planetary and cometary discoveries; more than a score for catalogues of stars and nebulæ; nearly a dozen for the determination of important constants (such as that of aberration); and among awards which are more miscellaneous in character the spectroscopic study of the stars has three times been honoured. The study of the Sun, however, appears in the list but twice, and only once explicitly. In 1857 the medal was awarded to Schwabe "for his discovery of the periodicity of the solar spots," and in 1862 to Warren De la Rue "for his Astronomical researches, and especially for his application of photography," which included, though incidentally merely, the invention of the photo-heliograph. The poverty of this record is striking, and seems to show, unless the Society has failed in its duty to an extent which I am not prepared to admit, that far too little attention has been paid to the Sun hitherto. It is a happy augury for the new century that we desire so early in its course to do honour to one of those who are taking the lead in rectifying the omissions of the past.

May we, before passing to his work, dwell for a few moments on the two awards of half a century ago which I have just

mentioned, those of 1857 and of 1862? They afford a background of some historical interest for the events of to-day and yesterday.

Heinrich Schwabe, a gentleman of Dessau, began to observe the solar spots very zealously with a small telescope in 1826, and continued for seventeen years before he made his modest announcement of periodicity in 1843. The announcement was entirely new and unsuspected. In the Presidential Address, on awarding the medal in 1857, Mr. Manuel Johnson showed how little the discovery had been anticipated by quoting from various eminent writers explicit denials that there was law, or anything regular, in the appearance of Sun-spots. And even when the eleven-year period was announced by Schwabe the subject attracted little attention, until Humboldt reannounced it in 1851 in the third volume of his *Cosmos*. We could scarcely have a more characteristic illustration of the strange, almost obstinate, neglect of the Sun and all concerning him which appears instead of the particular attention we might have expected.

Dawning solar physics was represented by Schwabe alone—a modest, patient, untiring observer. "Twelve years," says Mr. Johnson, "he spent to satisfy himself; six more years to satisfy, and still thirteen more to convince, mankind. For thirty years never has the Sun exhibited his disc above the horizon of Dessau without being confronted by Schwabe's imperturbable telescope, and that appears to have happened on an average about 300 days a year."

And then follows a paragraph on which I need make no comment; it is sufficient to remember that it was spoken to this Society in 1857.

"Let us hope that the example will not be lost. Men are apt to speak of astronomy as an exhausted science, meaning that all that can be known is known. No doubt, being the most perfect, it is in one sense the most exhausted science. But the astronomer of Dessau has taught us that there are still mines rich in ore, though they lie deep buried, and must be worked with more assiduity and with more care. I can conceive few more unpromising subjects from which to extract a definite result than were the solar spots when Schwabe first attacked them."

In 1862 Dr. Lee, in an able exposition of the many good works of Mr. Warren De la Rue, devotes about a page to "a department in celestial photography where Mr. De la Rue stands almost alone," that of *Heliography*. Although one or two isolated photographs of the Sun had been obtained previously, no uniformly successful method had been devised until Mr. De la Rue took up the problem. By applying the stereoscope to the pictures taken he showed that the faculæ were elevated above the photosphere, and he obtained traces of what were then called Nasmyth's willow leaves. His instrument, the Kew photo-heliograph, is so familiar to us that I need not dwell on its work,

but the following passage from Dr. Lee's address is of interest to us to-day :

"I cannot refrain from expressing my belief that the success already achieved by our friend warrants us in entertaining the hope that before long he will be able, with the aid of stereoscopic pictures, to exhibit to us the rose-coloured prominences depicted on the sensitive plates as plainly as the faculæ have already been photographed."

Considering the date (1862) this is a somewhat remarkable expression of opinion. It must refer to the photography of the prominences in full sunlight, for Mr. De la Rue had obtained pictures of them at a total eclipse two years before, and this fact is duly recorded in the address. And of course Dr. Lee can have had no notion at the time of the particular manner in which his prophecy would be fulfilled ; he must have been speaking merely from a general but deep-rooted confidence in the steady advance of scientific discoveries and methods. The achievement was not to fall to the lot of Mr. De la Rue, nor was it accomplished in his lifetime ; but within two years of his death not merely the prominences themselves but their *spectra* were photographed for the first time* in full sunlight by our medallist of to-day.

The thirty years intervening between this last event and Dr. Lee's utterance, though it is not marked by the award of any medal by this Society for solar physics, was still far from being a barren period. But it was a time of steady general work rather than of conspicuous individual achievement. The honours of the chief step in advance—the discovery that the prominences could be seen with the spectroscope in full daylight —were shared by at least three people, being predicted by one and realised independently by two others. It does not, however, concern us to-day to follow the history of this period. The work of our medallist is essentially more recent. It began, indeed, so early as 1889 with some experiments conducted at Harvard College Observatory on the photography of prominences with an improvised spectro-heliograph ; but his most remarkable achievements are not yet many months old. It is at any rate only within the last few months that we have had the pleasure of seeing on the screen the beautiful pictures which open up a new and vast field of research on the Sun.

We must, however, by no means neglect the early work which laid the sure foundations for these later triumphs. The experiments of 1889, though not very successful in themselves, contained the germs of the spectro-heliograph, and therefore of all the recent successes. In such a brief historical review, however, as can be attempted within the limits of this address we may begin with the year 1891, when the prominence spectrum was first photographed without an eclipse, as above mentioned.

* *Astronomy and Astrophysics*, vol. xi. (1892), p. 51.

The announcement of success was made to the British Association at the Cardiff meeting; and the paper is reproduced in the first number of the new journal *Astronomy and Astrophysics*, afterwards the *Astrophysical Journal*, which the energy of Professor Hale has done so much to found and maintain at its high level of excellence. Alongside the paper are placed two others by Professor C. A. Young and M. H. Deslandres, both containing similar announcements of success in photographing the spectrum of the chromosphere during the year 1891. Professor Hale's priority was of a few weeks only; and we may note with satisfaction the increased interest in solar physics which this threefold achievement implies. But he had already made a new departure by which he established a clear lead. In 1892 April he announced the successful completion of the spectro-heliograph, which represented, in his own words at the time, "a method by which photographs are now made of all the prominences visible round the entire circumference of the Sun with a single exposure, and by which faculæ are clearly shown even in the brightest portions of the Sun's disc." It is the latter part of this sentence to which I would call special attention. In the photography of the spectra of the prominences Professor Hale was one of several workers who reached results about the same time; but he was the first to realise that the faculæ could be photographed all over the Sun's disc, and thereby he curiously inverted the expectations of Dr. Lee. His special achievement was not only "to exhibit to us the rose-coloured prominences . . . as plainly as the faculæ," but to photograph the faculæ as plainly as the prominences; and in this achievement of 1892 the key note is struck of the theme which he has recently developed so magnificently.

The early history of a new idea is of such great interest that I will reproduce here verbatim Professor Hale's own account * of the manner in which he was led to his discovery.

"In his *Catalogue of the Bright Lines in the Spectrum of the Chromosphere*, published in 1872, Professor Young remarks as follows in regard to the H and K lines: 'They were also found to be regularly reversed upon the body of the Sun itself, *in the penumbra and immediate neighbourhood of every important spot.*' The observations referred to were made under the exceptional atmospheric advantages enjoyed at the summit of Mount Sherman, but even with the less favourable conditions common at the sea-level the same observer has repeatedly made out similar reversals in many spots. I do not know that these observations were confirmed elsewhere until the photographs made at this (Kenwood) Observatory in 1891 April brought out the same thing with great clearness. A few months later Professor Young secured at Princeton some photographs of the reversals, but my own attention has until recently been so fully

* *Astronomy and Astrophysics*, vol. xi. (1892), p. 413.

occupied with work on the prominences that I have had but little opportunity to go on with my proposed photographic study of spot spectra. Late in December, however, I secured some photographs of the spectrum of a spot in which the lines were so sharply defined that they were given a very careful examination. Not only were the bright lines at H and K more prominent in the penumbra than in the umbra of the spot, but their extent in the surrounding region was so great as to arouse the suspicion that similar reversals might be found on the disc, at points remote from the spot regions. To test this idea a series of six photographs of the spectrum was taken, the slit in each case being placed parallel to the position it had occupied in the exposure just preceding, and about 3′ distant from it. My expectations were not only realised by these photographs but greatly surpassed. In each of the six positions of a slit not more than 0·002 inch wide the K line was reversed in from 3 to 10 places. H was, without doubt, similarly affected in all of these points, but in some cases it was too faint to be certainly seen. Most, if not all, of these reversals were double, *i.e.* a dark line ran through the centre of the bright line, as is frequently observed in the spectrum of the electric arc. I have since suspected in several cases a strengthening of the broad dark absorption bands of the solar spectrum for a short distance on both sides of the bright reversals.

"Having thus found the surface of the Sun to be dotted over with regions in which the H and K lines are bright, I at once concluded that the *forms* of the reversed regions might be photographed with the spectro-heliograph in exactly the same way that prominences around the circumference are obtained. The first attempt to do this was made on January 12, when the adjustments of the instrument were incomplete, and connection had not been established between the accumulator and the clepsydra. In lack of more suitable motive power the slits were moved by hand, and even in this way bright forms near a spot group were shown on the photograph, though they could not be seen with the helioscope. The completion of the apparatus a few days later enabled me to secure very good photographs of the bright regions, and on comparing them with drawings and photographs taken in the ordinary way of faculæ near the limb it was found that the forms were identical."

It is almost needless at this date to describe the now well-known principle of the spectro-heliograph, but Professor Hale has himself given such a concise and simple statement of it recently that I cannot forbear quoting his words. "Imagine a direct-vision spectroscope," he says, "in which the eyepiece ordinarily employed is replaced by a (second) slit. If an image of the Sun is formed on the first slit of this spectroscope the second slit will permit the passage of only a narrow region of the spectrum corresponding in width to this slit. If the slit is now moved until it coincides with the Hβ line, for example, only hydrogen

light will pass through the instrument. If, then, a photographic plate is placed behind and almost in contact with the second slit, and the spectroscope is moved at right angles to the optical axis, an image of the Sun, in monochromatic hydrogen light, will be built up on the plate from the successive images of the slit. If the exposure is suitable the chromosphere and prominences will be shown surrounding this image."

It should be added that, though this principle suggested itself independently to our medallist in 1889, he subsequently learnt, and at once acknowledged, with that cordial appreciation of the work of others which he manifests unfailingly in his scientific writings, that it was not new, but had been stated essentially by Janssen as early as 1869, while instruments had been designed, and even constructed, by Braun and Lohse, in 1872 and 1880 respectively. But their experiments were unsuccessful, as indeed were the early experiments of Professor Hale himself. He was, however, the first to make a *successful* instrument and obtain results with it in the Kenwood Observatory.

It was completed early in 1892 and set to vigorous, regular, and successful work. Photographs of both prominences and faculæ were taken daily, and the importance of this new method of watching the Sun's activity was soon demonstrated, for in July the connection of a violent magnetic storm with faculous changes was clearly illustrated from the Kenwood photographs.* But before the end of the year which had seen its birth the doom of the Kenwood instrument was sealed. In the last number of *Astronomy and Astrophysics* for 1892 occurs a note about the 40-inch telescope of the Yerkes Observatory, stating that the large discs of optical glass made by Mantois for the University of Southern California had been purchased for the University of Chicago, and that Mr. Alvan Clark had contracted to grind the objective within eighteen months; that the site of the observatory was still undecided, but would probably be several miles outside the city. We know enough to recognise a rare piece of self-denial on the part of Professor Hale. We know that this great project, now carried to so successful an issue, originated in a visit paid by him and President Harper to Mr. Yerkes, a Chicago millionaire; and we know that Professor Hale must have foreseen the possibility, soon to become stern reality, that on him would fall the main work of founding a great observatory, which would necessitate the neglect or temporary abandonment of the infant spectro-heliograph which had just been born to him with such promise; and we know that he never flinched for a moment in the choice between his own personal work, sure and important

* Professor Hale's recent work, showing the astonishingly different results which may be obtained by setting the slit on a slightly different position of the broad K line, have given a new importance to questions of adjustment. Seeing that the spectro-heliograph was dismounted during July, it is just possible that some of the conclusions from these early records may need modification.

though it was, and the laborious and hazardous enterprise which might, if successfully piloted, make it possible for others to do great work. We know too with what rare skill and devotion he did pilot this enterprise, so that the Yerkes Observatory, the very site of which had not been determined a dozen years ago, now ranks not merely in magnificence of equipment, but in solid and brilliant work done, among the foremost in the world. We are content that our medallists should do one thing well, though it often happens by good fortune that we can find more than one excellence to admire in them; but I venture to think that we have seldom had a better example of versatility than on the present occasion, when we find the same man initiating and conducting a new and important journal, initiating and establishing one of the foremost observatories, inventing a new instrument which has an obviously great future before it, and recently finding an entirely new field of research for that instrument.

To attempt to follow the activities of such a man during a dozen years in the space allotted to this address would be merely bewildering; to touch on a few of the salient points is all that is possible. I will ask you to pass rapidly over the events of about ten years during which the Yerkes Observatory was being built and equipped. During the first three or four the spectro-heliograph was in regular use on every clear day at the Kenwood Observatory, and a series of valuable records was thus obtained, which is still in existence and of which we hope to hear more. But in 1895 May this series was interrupted by the dismounting of the instrument for removal to the new Yerkes Observatory, where it was hoped soon to remount it. Unfortunately there came a series of unexpected delays. The 12-inch telescope was wanted for other purposes, and to use a spectro-heliograph on the 40-inch telescope meant making a new instrument, for which funds were at first not forthcoming at all, and then came but slowly. There were difficulties in finding suitable lenses; and, worst of all, an accidental fire destroyed a nearly completed instrument. Looking back on the enterprises in hand during these years, our surprise must, however, be not that such delays occurred, but that they were not more effective. Patiently and resolutely each difficulty was met and conquered, and within four years (in 1899) the new and improved spectro-heliograph was ready for trial; within four more it was successfully at work exploring an entirely new domain of solar physics. A full description of this beautiful instrument has just been published in the third volume of the "Yerkes Observatory Publications." "The design finally adopted was reached only after long and careful consideration of the special conditions of the problem," after numerous forms had been designed, and some of them actually tried. Professor Hale states clearly his opinion that "the ideal form of spectro-heliograph is that in which the instrument is moved as a whole, while the image of the Sun and the photographic plate are stationary." But this presupposes a fixed telescope with some form of heliostat. To

attempt it with a large equatorial would be to throw the telescope into vibration and render good images hopeless. The only feasible solution of the problem seemed to be to move the Sun's image across the first slit by a motion of the telescope, the photographic plate being moved sympathetically across the second slit: and accordingly the telescope is moved in declination by the slow-motion motor. As regards dimensions, the slits are eight inches long and properly curved: the collimator and camera lenses are $6\frac{1}{4}$-inch Voigtländer portrait lenses; and two prisms in conjunction with a mirror give a total deviation of 180°. These figures, however, though they suggest a fine instrument, give no idea of the care and trouble necessary to work it. The principle of the spectro-heliograph is exceedingly simple, but the working of the instrument is quite sufficiently complex. In the description of it Professor Hale gives, under the heading "Adjustments,"* a list of *thirteen* distinct operations to be carried out with great nicety before a satisfactory photograph can be taken. We can imagine a veteran transit-circle observer thanking Providence that he was not born in these days. An important feature in the design is the method of setting the second slit on any desired line in the spectrum; we may almost say on any desired *part* of any line, for it is by the partition of the broad K line into significant regions that Professor Hale has within the past year opened up a new field of research with this instrument, of which I proceed to speak. But I will first follow his example in uttering a word of caution against too literal an interpretation of what is only intended as a working hypothesis. "The hypothesis," he says,† "is used mainly as a guide to further research, for, while it seems to describe in a fairly satisfactory manner many of the phenomena photographed, it is, of course, open to modification or rejection in the light of future results."

With this caution in mind we remark in the first place that what are called the H and K lines in the solar spectrum are not narrow and simple lines, but wide and complex bands. Since a line may be widened by pressure of the vapour producing it, sources of light at different pressures will give bands of different widths; and if the results be superposed, then at the middle we shall get light from all the sources, though at the edges we shall only get that from the source where the pressure is greatest. If we put the slit of a spectro-heliograph on one of the edges we get light from this source of great pressure *only*. Now in looking at any point of the Sun's disc we get just this state of things: we receive light from the successive sections of his surroundings traversed by the rays; and the pressure, and therefore the width of the band, will be different for each section. By putting the slit of the spectro-heliograph on an edge of the wide H or K band, however, we exclude the light from all but the section at greatest pressure, and practically view this section only. We can cut it out of the

* *Yerkes Obs. Pub.* vol. iii. p. 12. † *Ibid.* p. 13.

Sun's atmosphere as cleanly as a biologist cuts out a section of a specimen for microscopic examination. But we cannot proceed, as he does, to cut other sections as cleanly; for by moving the slit within the edge of the H or K line we get light not from the section of next greatest pressure only, but from it and the last combined; and as we go further inwards the complexity increases. We must also remember, though the fact has been omitted in what precedes for the sake of simplicity, that the continuous spectrum is also superposed in all cases. But it is clear that by setting the slit to various positions on the broad band different results will be obtained, from which it is not hopeless, though it may be very difficult, to compile a complete account of the form of the calcium vapour at different levels in the Sun's surroundings.

One thing is to be specially noted. Professor Hale may be photographing faculæ, but he is certainly not photographing faculæ *alone*. A more general term is required for the whole class of phenomena to which faculæ are closely related; and Professor Hale has suggested the name *flocculi*. The phenomena vary not only with the setting of the slit in different parts of the H or K band, but with a change to the line of a different element. On changing, for instance, to a line of hydrogen the remarkable fact is disclosed that, whereas the calcium flocculi are bright, those of hydrogen are *dark*; and, following up this result, Professor Hale has since found that even calcium flocculi are sometimes dark. Indeed, new results are multiplying so fast that it is perhaps prudent not to attempt to summarise them here. A new degree of freedom has been imparted to solar research by the discovery of this method. The new development is still in its infancy; but we have already had some most beautiful illustrations of its practical working exhibited to us, and from these alone we may confidently predict a great and important future for the study of the "flocculi."

I am tempted by the new name to make one more reference to the events of forty years ago. It fell to my lot on succeeding to the Savilian Chair at Oxford to collect for publication the astronomical correspondence of my predecessor, the Rev. Charles Pritchard. Among the letters were a number dealing with Nasmyth's discovery of "willow leaves" in the surface of the Sun, which created great excitement at the time, and led to a voluminous literature, now practically obsolete. A few of the letters were selected for publication,* and from the first of them it appears that the earliest confirmation of Nasmyth's views originated in an observation made by De la Rue in Pritchard's observatory at Freshwater; and Pritchard attributed the detection of the "willow leaves" to the use of the new solar eyepiece, suggested by Sir John Herschel, to whom he was writing. An

* *Memoirs of Professor Pritchard* (London: Seeley & Co., 1897), p. 240.

eyepiece with one reflection from a piece of plate-glass and a neutral-tinted shade was the most elaborate addition made to the telescope for solar work in those days. The second letter, to the same person, opens with the following words, which recurred to my mind on hearing Professor Hale's new name for solar phenomena :

"We had a strong debate on 'willow leaves' last Friday evening. Mr. Dawes will have it that he sees nothing but a 'flocculent precipitate.' Our 'willow leaves' are a sort of 'crystalline precipitate.'"

The date of this letter is 1863 December 15. May we hope that the shade of that highly strung, keen-eyed observer, W. R. Dawes, will rest the more peacefully now that, just forty years after he did battle for the flocculent precipitate,* the term flocculi is re-introduced into solar physics by so competent an authority as our medallist of to-day ?

I have already disclaimed any intention of giving a complete account of Professor Hale's work ; but there are at least two important researches, independent of his work with the spectro-heliograph, which must be mentioned.

The first is his determined search for some method of observing the corona without an eclipse. Hitherto it has been unsuccessful, but that is owing to the difficulty of the problem, and not to any lack of skill or assiduity in the attack. A special expedition was made to Mount Etna in 1894 to try one of the experiments, and Professor Hale, after erecting the instrument and making the early observations himself, left the work for further trial in the able hands of Professor Riccò, who, however, had no better success. Several distinct methods have been tried at different times, utilising both the ultra-violet end of the spectrum and the heat radiation, the suggestion for exploring the corona with the bolometer being particularly happy, as it depends on a differential observation which ought theoretically to eliminate the sky glare ; but even this ingenious attack has been hitherto fruitless, for the coronal heat radiation, as has been shown from experiments made by Langley at a total eclipse, is extremely small compared with its light radiation.

Secondly, I must make a brief reference to the work done at the Yerkes Observatory from 1898 onwards in photographing the spectra of the fourth-type stars and measuring the photographs. The results of this laborious and thorough investigation have just appeared as one of the Decennial Publications of the University of Chicago. It contains 135 quarto pages of closely printed text and tables, and eleven beautiful plates. Forty-three photographs of the spectra of eight stars were selected for measurement, preference being given to well-established results

* See also *Mon. Not.* xxix. p. 119, line 36, where the word "flocculi" is actually used.

in a few cases. The stars being all faint, the research was a specially appropriate use of the great telescope; but at the same time the difficulties introduced precluded any very great accuracy being obtained, as is frankly announced in the volume. Nevertheless the results for motion in the line of sight show a precision which is by no means to be despised. An average of 15 lines for each star were compared with known positions for terrestrial elements, and velocities ranging from $+4km$ to $-28km$ per second were deduced. A corrected table of 537 lines in these spectra is then formed. Such figures may give some idea of the amount of work represented and the thoroughness with which it has been done. There follows a most able and interesting discussion of the physical character of these stars, summarised in fifteen conclusions, the last of which is that "fourth-type stars probably develop from stars like the Sun through loss of heat by radiation"; and though the other fourteen which lead up to it are full of interest I can here select one only for mention. Professor Hale finds a noticeable agreement of the fourth-type spectra with those of Sun-spots. In the region which is not masked by the carbon flutings the forty-six lines which are most strongly and frequently widened in the spots, as recorded in the *Greenwich Results* for 1880, are found to be the most prominent dark lines in the star. Hence it is suggested that spots similar to those on the Sun may possibly be numerous in fourth-type stars.

This result is in itself a justification of the twofold attack on the problem of the Sun, and carries us back to the proposition which I quoted at the outset—"It cannot be too often repeated that the Sun is the only star whose phenomena can be studied in detail." The reasons for studying Sun and stars side by side are obvious: and there is still a third line of research, necessary for properly conducting both the others, to be carried on in the laboratory. That Professor Hale is fully alive to this third necessity we have evidence in his exhaustive investigations of the fluting of magnesium in 1890: and in his work on the spark spectra of metals in liquids and under pressure, recently completed but awaiting funds for publication. It is perhaps noteworthy, and to many will come as a surprise, that one of the chief difficulties encountered by our medallist throughout has been lack of funds; for it is liable to be forgotten that other things are wanted besides a large telescope itself, and the funds for publication are the most likely to be forgotten of all. Several times the deficiencies have been supplied by the father of our medallist, the late William E. Hale; and later from a fund established in memory of him by his children, including of course our medallist himself.

I have indicated the great variety of Professor Hale's activities. It remains to be added that they are connected by a notable unity of purpose. Throughout this address I have quoted freely from his writings as the simplest and most efficient way of explaining the value of his work; and I will quote once

more, in order that this purpose may be declared in his own words. He is, of course, not speaking consciously about himself, but of the "aims of the Yerkes Observatory." In his address * at the Dedication, in 1897, he said—

"If I mistake not the signs of the times the Yerkes Observatory can render no better service to both astronomy and physics than to contribute, in such degree as its resources may allow, towards strengthening the goodwill and common interest which are ever tending to draw astronomers and physicists into closer touch. During its three years of publication the *Astrophysical Journal* has had the same end in view. The annual meetings of its editors, of late devoted mainly to the informal discussion of astrophysical investigations, have invariably been of great interest and value."

These are no empty sentiments; they are the words of a man who organised under the name of a meeting of editors the first gatherings of astrophysicists in a land where, owing to the wide separation of workers, scientific gatherings are far more difficult than for us; of a man who took special care that at the Yerkes Observatory physical laboratories should exist side by side with telescopes and spectroscopes; and especially of a man who could cheerfully lay aside his own fascinating work for the general good in founding a great observatory. We recognise in our medallist one who has more thought for others than for himself; and I am sure it would be his own wish that before concluding this address I should say one word in recognition of the efficient help which he has received from others, as it is only to be expected he would. To select any one name among many may be invidious, but that of Mr. Ferdinand Ellerman, who has been associated in all Professor Hale's work, experimental and otherwise, for the past thirteen years, and whose able assistance is often acknowledged by him with gratitude, is certainly worthy of mention to-day.

It is, of course, a disappointment to us that Professor Hale cannot be here in person to receive the medal, but we have knowledge which mitigates the disappointment. If our medallist had pleaded that the journey was too serious we, who so seldom venture to cross the Atlantic from this side, could scarcely have objected to the plea, though we might have urged that a visit to Europe had on at least one occasion proved apparently beneficial to him; for we remember with gratification that he returned from the meeting of the British Association in 1891 to originate the spectro-heliograph and the new journal of *Astronomy and Astrophysics*. But Professor Hale enters no plea of the kind. That he is not on our front bench, where we should have been so delighted to see him, to-day is due simply to the fact that he is filling a place of even greater honour: he is initiating a new work of science.

* *Astrophysical Journal*, vol. vi. (1897), p. 310

He was led to pay a visit to California, to study the conditions for solar work, and found them so admirable that he felt compelled to commence operations at once on such a modest scale as is possible with his present very limited resources. We shall earnestly hope that these will soon be supplemented in such a manner as to put the new enterprise on a proper basis. Those who have the administration of funds for scientific research doubtless find the choice between various admirable proposals no easy matter. Indeed, we hear of more than one new project in which Professor Hale himself is interested. We hear not only of a possible new solar observatory, but of a somewhat novel type of observatory in the southern hemisphere; and no one who knows anything of the recent history of astronomy can fail to recognise the pressing importance of both these needs. The southern hemisphere has been unduly neglected from the first, and the leeway to be made up in studying it becomes greater every year. If half a dozen new observatories instead of one were established in the southern hemisphere to-morrow it would take them many years to atone for past neglect.

But there are equally strong reasons, having their origin in undue neglect in the past, for the establishment of a new solar observatory, as I endeavoured to show in the early part of this address. If Schwabe "taught us that there are still mines rich in ore" by merely counting the Sun-spots, what vast new gold-fields has not Professor Hale prospected by showing that every spot, which to Schwabe was a mere unit, is a region which must be explored from hour to hour, from section to section, and from one chemical element to another! He has pointed out the defective state of our knowledge as clearly as Flamsteed did two centuries ago; and, when the obvious need of a fine steady climate for the work is added, he has made out just as good a case for the foundation of a solar observatory as did Flamsteed for the foundation of the Royal Observatory at Greenwich. And if by good fortune it should be founded and the query should again be put, "Who is to take charge of it?" let us hope that the answer will be, in the words of King Charles II., "Why, he who told us the need of it!"

But it is unprofitable to venture on the quicksands of anticipation when we can tread on the solid ground of accomplished fact. I have surely said enough, however imperfectly, to justify to you fully the award of the Council, and it remains only to hand to the American Ambassador for transmission to Professor Hale the outward and visible symbol of our esteem.

The President then, addressing the American Ambassador, said:

"Mr. Choate, it is but three years since your Excellency did us the honour to attend our Annual Meeting to receive the

medal on behalf of Professor Pickering. It is, in every way, a great pleasure to us to see you here again so soon.

"It will, I am sure, not lessen the value of this medal which we ask you to send to Professor Hale as a token of the high value we set upon his work if I add that it is also, in some sort, a symbol of our cordial admiration of the great advances made in our science by the astronomers of the United States and those citizens who have so generously aided them."

The meeting then proceeded to the election of Officers and Council for the ensuing year, when the following Fellows were elected :

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H. H. Turner, Esq., D.Sc., F.R.S., Savilian Professor of Astronomy, Oxford.

Vice-Presidents.

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Captain William Noble.
A. A. Rambaut, Esq., D.Sc., F.R.S., Radcliffe Observer.